

Team 17.3 Final Design Report: EasyPour

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Executive Summary

We worked with Jennifer Flaxman from Park School to design a more independent pouring device for students with limited fine motor skills. Park School's current switch-activated pouring device lets students participate in pouring, but requires teachers to refill the material, reposition the containers, manage spills, and reset the process after each use; this means students only independently complete one part of the task, leaving room for more student independence.

We conducted background research, user observations, client interviews, design reviews, prototype testing, and final feedback interviews to understand how our users will interact with the pouring device. Through this process, we identified our two main requirements: the device had to connect to accessible switches, be easy to operate, be able to fill at least five containers, and be compatible for students with varying abilities.

Based on these identifications, we have focused on independence and accessibility as the two most important design bases for our design, the EasyPour. The device uses two mechanisms that make the pouring process more independent for both students and teachers. The first mechanism is activated by using an accessible switch in which an upper storage of materials moves into a rotating auger that dispenses a cup's worth of material into a container below. The second mechanism is activated by another switch, in which the plate the cups sit on rotates to the next cup position.



Figure 1: The EasyPour device

The final prototype successfully demonstrates a switch-activated system that dispenses dry granular materials into multiple cups with significantly less teacher assistance. For future development, the most important improvements would be making the device able to dispense liquids, making the device food-safe, and providing more precise pouring. With these improvements, the EasyPour would become more effective in teaching various pouring tasks, further increasing independence of students.

Introduction

Park School in Evanston, Illinois, is a therapeutic day school dedicated to educating students with a wide range of disabilities through individualized education and vocational training. Supporting students ages 3 through 22, the school was founded on independence, accessibility, and hands-on learning experiences that prepare students for everyday tasks and for a future in the workplace [1]. By providing a specialized curriculum for each student, Park School provides a learning environment fit for all students. (See Appendix A)

School is not simply a place to learn new subjects, but to build new pathways to complete tasks with disabilities. Simple actions that many overlook, such as pouring a drink, filling a container, or passing a cup, can be challenging for students with limited fine motor control. Through accessible technology, Park School allows students to practice tasks in a way that builds confidence, independence, and accomplishment as they can be completed more independently.

However, while the school's current switch-activated pouring device allows students to participate in the action of pouring a material into a cup, the task is not fully designed for total independence. Teachers must constantly refill materials, reposition the containers, monitor spills, and reset the system after use, meaning students are only completing one small portion of a full task.

Our project partner, Jennifer Flaxman, Transition Coordinator & Teacher of the Deaf and Hard-of-Hearing, has a current device for students to perform pouring actions, but is looking to redesign it for more student involvement and less teacher dependence (See Appendix B). The current device consists of a mount with a motor connected to a peg with a cup on the end. This motor is activated by a connected button linked to a PowerLink adapter, which allows multiple accessible buttons to be plugged into it. The teacher pours salt, rice, beans, or another material into the cup, and when the button is pressed, the motor rotates the cup counterclockwise and pours the material. Most of the steps to complete the pouring task require teacher assistance; the improvements are designed on the principles of independence and accessibility.

To address these challenges, our team developed an automated switch-activated dispensing system designed to be used independently by students with varying disabilities. The design focuses on reducing physical effort, minimizing teacher assistance, and focusing on having a limited number of inputs. In our preliminary user testing, we defined the key features and separated them into two categories being “must haves” and “nice to haves”. (See Appendix C) The new system combines an automated dispenser with a motor-powered auger. When the attached accessible button is pressed, an auger in a tube transports materials from an upper container towards an opening at the end of the tube, which is funneled to a cup below. The cup below sits on a lazy-susan plate with six indented holders for cups to sit in. This lazy-susan plate is spun using a different accessible button, which rotates the plate to each indented position,

allowing for multiple containers to be filled without manual repositioning. The design prioritizes intuitive operation, cleaning ability, and compatibility with multiple granular materials, ranging from salt to beans. After the feedback we got on the preliminary mockups, we 3D printed and formed the actual prototype for Ms. Flaxman's review (See Appendix D).

The following sections of this report will include the secondary research behind the design that inspired and informed us (See Appendix E), the users, requirements, and design specifications for the system, bill of materials (See Appendix F), as well as an explanation of the design concept and rationale. We will then discuss the system itself and steps for construction (See Appendix G) and use (See Appendix H), ethical considerations (See Appendix I) as well as suggestions for future improvements. Finally, we will conclude by summarizing the feedback we got from the client (See Appendix J), providing the mockup sheets that helped us learn what to improve about our ideation process (See Appendix K), and reviewing our design (See Appendix L).

Users and Requirements

Main users of the design

Park School Students: The main users are Park School students who have limited arm control and want to pour granular materials such as salt or rice into salt shakers or cups.

Park School Teachers: Park School teachers would initially demonstrate and teach how the students are supposed to use the pouring device. Teachers first learn the device themselves, then teach students how to use it. Afterwards, they would operate as facilitators when students are completing the task individually.

Vocational workers: The device may be used by students outside of Park School for vocational use, such as pouring scenarios in the workforce.

Main requirements

Through our initial guidelines, background research, and expert interviews, we identified the following guidelines for our device:

Capacity: The solution must fill up at least 5 cups or salt shakers at a time.

Switch Activation: The solution must be activated by ergonomic switches. The switches should trigger the action once they are pressed and shouldn't require constant pressing. Furthermore, they should not require excessive force and should be placed conveniently to follow ADA guidelines [2].

Automation and Independence: The final solution should be automated, reducing the physical labor and teacher intervention. This way, the students will be able to fill more than one cup or salt shaker without having to ask for help from another person. Furthermore

Design Concept and Rationale

The EasyPour is a horizontal auger dispenser that automatically dispenses dry granular materials and rotates through containers via external buttons. The design consists of a large tank and a funnel for the material to be dispensed, which enters the horizontal auger tube. The auger, driven by a motor, carries the material laterally and dispenses it at a consistent rate. The base plate has a lazy susan top that rotates through containers via a stepper motor, allowing multiple containers to be filled in succession. Both motors are controlled by a microcontroller and powered by a wall outlet, which takes input from external wired button switches that can be mounted in any manner. We designed different parts of the device with modularity in mind, as we had to think about how the device was actually assembled. For example, we want to keep electronics fully concealed, but once a stepper motor is inside an enclosed casing, we cannot screw it in from the outside. Factors such as these increased the difficulty of our design, especially since cleaning the device requires some disassembly/assembly.

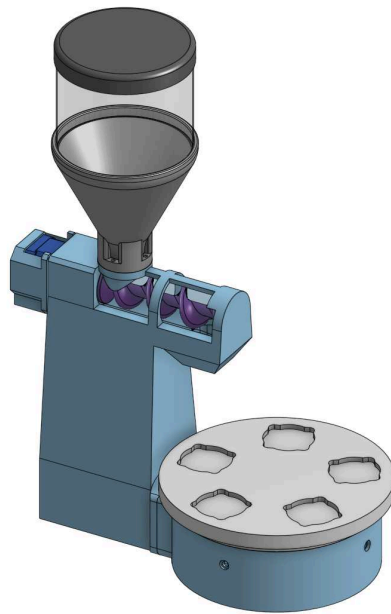


Figure 2: CAD Model of EasyPour

The first part of the device is the lazy susan, containing the rotating cup holder (the baseplate). It uses a lazy susan bearing to allow smooth rotation of the baseplate. We used a 200 mm outer diameter, which allowed us to keep the device compact. From our interviews and observations, the teachers at the Park School loved the idea of a lazy susan, hence we decided to incorporate this into our design.

For the baseplate itself, we created holes when 3d printing based on the hole locations in the bearing. This lets us use heat set inserts to connect the baseplate to the bearing, instead of 3D

printed threads, which are often unreliable. The baseplate itself also has holes which fit both the salt shakers and cups provided by Park School securely, allowing users to use both containers. These were sized by using a caliper to measure the base diameters of each container.

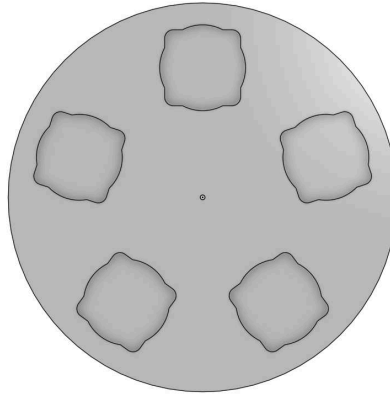


Figure 3: Top View of CAD Model of Lazy Susan Plate

Furthermore, the baseplate and bearing sits on the outer walls of a casing that houses the electronics. The height of these walls were sized so that the stepper motor rests on the bottom layer of the case while the outer ring of the bearing rests on the walls of the case, distributing pressure evenly. Inside the casing, there are also walls in the center which hold the stepper motor in place, eliminating unintentional rotation and imprecision.

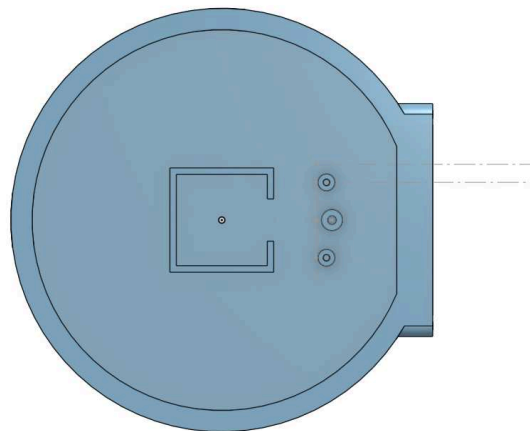


Figure 4: Top View of Lazy Susan Case, with Walls for Stepper Motor in Center

The outer walls of the casing also have precisely shaped holes with shoulders, allowing us to directly mount MONO jacks and power jacks, so buttons and wall power can be plugged into the device, while all wiring remains hidden.

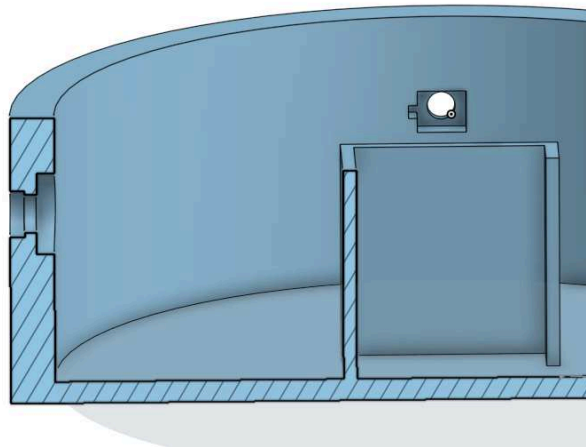


Figure 5: Cross Sectional View of Lazy Susan Case, with Holes for Jack Mounts

Since we were designing with assembly in mind, we were mindful of how to integrate the lazy susan with the auger. To that end, we went for a modular design, designing components individually but leaving areas for them to connect via screws. We left a rectangular hole and mounting area in the casing walls with heat set inserts on the outside where the auger could connect to, allowing us to assemble easily while also creating extra space for electronics (we wanted these to be fully enclosed). Furthermore, the casing floor has protruding bosses that allow the mounting of the prototyping board, which was necessary as the board was too long to be enclosed in the lazy susan part of the device alone. Lastly, we ensured sufficient space inside the casing for housing electronics and wiring.

During the prototyping phase, we got many dimensions wrong, but since we were manufacturing using 3D printers, we could rapidly prototype and test new designs by printing at only 5% infill. For the final product, we printed using four wall loops, five top/bottom layers at 1mm thickness, and 25% infill with a gyroid pattern for higher strength and quality. Most heat set inserts were compatible with M3 screws, which are common and are widely available in different lengths, which made them suitable for the different screw length requirements in our device. We did use two M2 threaded inserts for mounting the prototyping board, but this was due to the manufacturer's specifications.

The next part of the device is the dispenser. As another modular part, it connects to the lazy susan via M3 screws and can be easily disassembled. A stand supports the stepper motor/auger/transparent polycarbonate tube, while providing height and distance away from the baseplate providing the needed space for dispensing. The stand is also hollow inside, allowing the wires of the stepper motor to connect to the prototyping board.

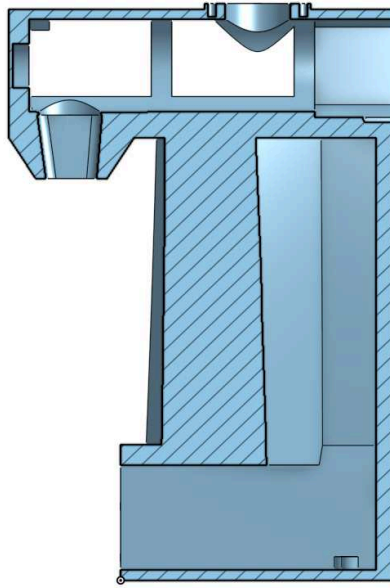


Figure 6: Cross Sectional View of Auger Stand with Hollow Interior

The tube housing the auger is also transparent, so the kids at the Park School can see the auger spinning and material being dispensed in real time, which made the device more entertaining. The floor of the dispenser stand is the same height as the floor of the lazy susan casing, and has identical protruding bosses as the lazy susan. This continuous geometry comfortably supports the protoboard, greatly reducing its deflection. The horizontal length of the stand was also sized to accommodate the length of the protoboard.

For the dispensing mechanism, we opted for an auger. An auger was a good solution as, combined with a stepper motor, we could easily control the amount of material dispensed by simply adjusting the number of rotations.

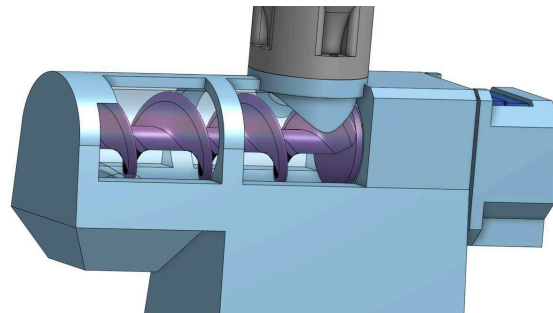


Figure 7: The Auger inside the Polycarbonate Tube

We also considered other solutions such as buying a pre-built dispensing machine, but these were too large, looked out of place, and the dispensing mechanisms were hard to control (they

typically use a lever actuated motion). Hence, we opted for an auger which was both compact and easily controllable. The auger has a flat plate towards its attachment end, preventing backflow of material.

The auger came with its own assembly challenges. We had to secure the auger, the tube, and the stepper motor, but once components were inside the tube, we couldn't reach inside to secure anything in place. Furthermore, the stepper motor is designed for frontal mounting, which points into the tube (we also couldn't reach it once inside). We also needed a reliable way to disassemble the dispenser for cleaning. We solved this problem by attaching the auger to the stepper motor via heat set inserts in the auger, and attaching the stepper motor to a specially designed "cap." The cap had frontal mounts for the auger, but also mounts on its back, allowing it to screw into the rest of the dispenser during assembly. To remove the auger, we simply remove these screws, and pull out the cap, stepper motor, and auger as a unit. The auger can then be unscrewed for cleaning.

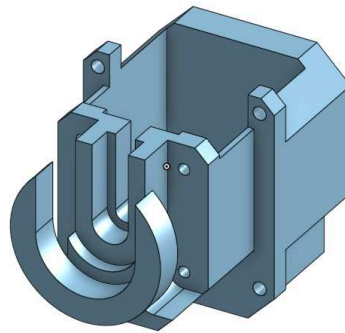


Figure 8: Cap for holding the Stepper Motor

Since one requirement from the Park School was to reduce the device's reliance on teachers, we added a container with a funnel to the dispenser, funneling goods via gravity into the polycarbonate tube. The container can store over $\frac{1}{2}$ gallon so teachers do not constantly have to refill. Like the other parts of the device, both the funnel and container are modular and can be unscrewed for cleaning.



Figure 9: Container for Holding Granular Goods

Similar to the polycarbonate tube, the container is clear, which not only makes the device more entertaining since kids can see the flow of goods, but also allows teachers to easily see whether a refill is required. Lastly, we kept our device compact, increasing its aesthetics and staying within the Bambu Lab X1C's 256 mm printing dimension limit.

For the electronics driving the device, one initial question we answered was how it would be powered. We decided to go for a wall power approach, so that no recharging of batteries was necessary. We also had to figure out whether the entire device would be powered this way, or just the steppers (with the microcontroller being powered via battery), and what components/wiring we would need to achieve this. Wall power is rated much higher than what microcontrollers and servos can handle, and we also needed a way to convert this power into something we could control using wires on a breadboard. To tackle these issues, we bought a wall power to 12V converter, which gave us a voltage we could use for stepper motors. However, to channel any current into wires we could control in a circuit, we also bought a mountable 12V to wire adapter, so that users could simply plug the wall power into the device and the power would make its way into our circuit.

While 12V was a comfortable operating voltage for our two stepper motors, it was too high for most microcontrollers, which are required to control the button-actuated stepper motor rotation logic. Hence, we decided to pick an Arduino Nano as our microcontroller. The Nano has an onboard 12V to 5V regulator. This means that we could run two voltages in our circuit, the original incoming 12V for the stepper motors, and the converted 5V for our HIGH/LOW logic. Furthermore, with a clock speed of 16MHz, the Nano was more than enough for simple stepper motor logic. Some alternatives we considered were the ESP 32 and Raspberry Pi Pico, which we rejected due to their lack of 12V - 5V regulators and because we didn't need remote capabilities (ESP 32) or higher clock speeds (Pico).



Figure 10: Arduino Nano used in Device

Next, we had to figure out what rotation/dispensing actuator to use. We considered servos, but didn't choose them because stepper motors provided higher torque and greater precision at low speeds (exactly our operating conditions for both the lazy susan and auger). Like other groups, we also considered DC motors. We didn't choose this option because a DC motor does not take a precise angle as an input, but rather voltage. If we blindly supplied 12V to a DC motor, it would spin very fast without any control of its angle. To precisely control the angle of a DC motor, we would need to use complex PWM code in a cascading control loop, along with an h-bridge and current sensor, which is possible but requires more time and effort without providing any benefit over a stepper motor. Ultimately, we went with the NEMA 17, which provides 44 N * m of torque, sufficient for our purposes (rotation and dispensing granular goods).

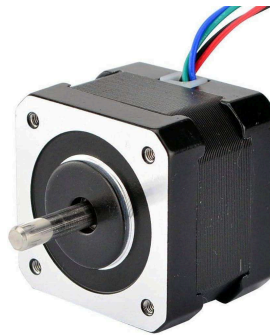


Figure 11: NEMA 17 Stepper Motor

Each stepper motor is driven by its own A4988 stepper driver, which is a standard choice for the NEMA 17, capable of handling 12V of current. We carefully tuned the onboard potentiometer, finding the middle ground that allowed enough current (for torque) while preventing overheating. Heating was a very important issue, as our electronics are largely enclosed; hence, there is no easy outlet for heat to escape. Ultimately, the drivers provided enough torque while largely eliminating any overheating risk, allowing for continuous use of the device. Additionally, we used an electrolytic 100 microfarad capacitor rated for 50V on each driver, preventing the drivers from breaking on device startup.

For the button-triggered logic, we combined the mono jacks with the Nano's internal pull-up logic. When the button is pressed, an input pin on the Nano goes from HIGH to LOW, and the

code written in C++ and flashed to the microcontroller in the Arduino's IDE drives the stepper motors (we define the angle of rotation).

We didn't want the users to have to think about the electronics, see exposed wiring, and we wanted to keep our connections secure. Hence, we used a solderable, breadboard-style prototyping board over a breadboard, which could easily be mounted on the bosses we designed inside the device. We first prototyped the working circuit on the breadboard, then soldered the circuit onto the protoboard. The microcontroller, stepper wires, and stepper drivers were never soldered directly. Instead, we soldered female/male pins for these components onto the board, so the components could be manually and securely plugged into them. This meant that if any of these components broke, they could be easily swapped out for new ones.

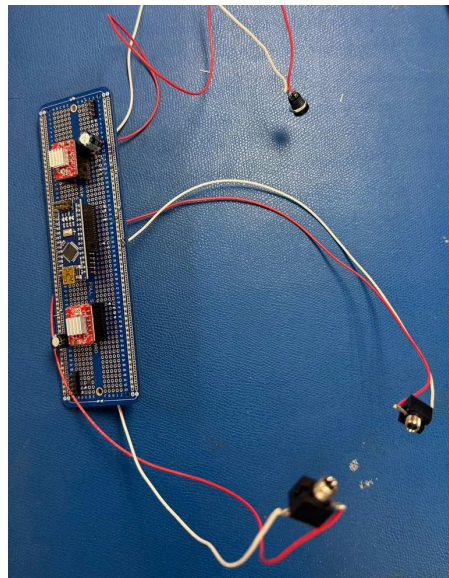


Figure 12: Finished Protoboard

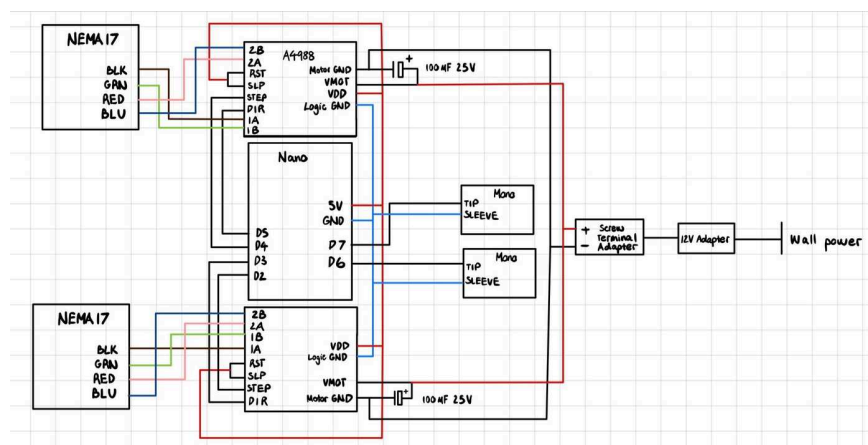


Figure 13: Circuit Diagram used in Device

Directions for Future Development

Proposed Additions for Full-Scale Development

Since the prototype developed at the Segal Design Institute needs to be upsized, DTC Team 17.3 proposes the following additions to the full-scale development of the pouring solution. These additions would concentrate on increasing the capabilities of our product being the variety of types of materials we can pour, how precise the pouring would be, making the parts food safe, and increasing the compartment quantity.

Integration of Liquid

Our client prioritized the pouring of granular material over pouring liquid but stated that it would be a valuable addition. This way, the students would be able to pour water for their friends, pour drinks at restaurants, etc. This can be achieved through utilizing water-sealed containers on top of the auger. This way, water leakage would be prevented, reducing the risk of damaging the electronics and making a mess.

Another way of integrating liquid would be by upgrading the design in several ways. The current auger-based system could be transformed into a liquid dispensing application by integrating a peristaltic pump system in place of an auger, which is controlled through the same switch-activated motor system. The peristaltic pump compresses a flexible tube and pushes liquid forward through the system. Inside the pump, rollers attached to the motor continuously squeeze the tubing as they rotate. This creates pressure, which then moves the liquid in the desired direction [9].

Food Safety

For better use of the system in vocational and everyday settings, another design modification could be the use of food-safe materials. Most of the design materials for the rotating plate, auger, and mount were made using Polylactic Acid, or PLA, which is a thermoplastic polyester. This material is not food-safe from 3-D printing, as the nozzle of 3-D printers can be dirty, and the physical nature of PLA's printing leaves tiny holes in which bacteria can grow. Furthermore, while the base of PLA can be food-safe, colors or additives from manufacturers can make it toxic for consumption. Therefore, in a redesign of the current prototype, changes in the physical properties of the product to make it food-safe would allow for more applications of the device.

To make a 3-D printed object food-safe, the object should also be sanded thoroughly before the sealant is applied to ensure a smooth, even layer of epoxy is applied. The piece should also be washed to ensure all debris and microplastics are washed off. The object has to be sealed with a food-grade epoxy resin, such as ArtResin, which makes it difficult for bacteria to grow. After sanding and cleaning, apply an even layer of epoxy, ensuring that it is completely sealed. Furthermore, using a printer with a stainless steel nozzle instead of brass can prevent objects

from being contaminated with lead, and special printers that are designed for food safety would provide the best guarantee of safety.

Precision Pouring

The future development of increasing precision can be achieved by integrating a volume sensor to enable a more accurate pouring. Instead of relying on the duration the motor runs, a volume sensor would measure how much has been poured into it. This way, each salt shaker/cup can be filled with equal quantities. The system would operate until the target volume is reached and would automatically stop the pump when it is achieved.

Compatibility with Different Types of Switches

Another potential future development would be increasing the system's compatibility with different types of accessible and ergonomic switches. While the current prototype is using the most commonly utilized ergonomic switch being the button switch, different students require different types of switches, not limited to but including chin-mounted switches, finger switches, etc. This way, we would be able to increase the number of students who can benefit from the solution.

Implementation of Multiple Compartments

Implementing multiple compartments within the dispensing system would enable teachers to organize more exercises without having to empty, clean, and change the upper container after each exercise. A multi-compartment design could improve convenience, reduce setup time, and increase the flexibility of the device for different training or educational tasks.

Conclusion

Our goal for this project was to redesign and upgrade the Park School's already existing switch-activated pouring mechanism. Their current solution worked; however, it required a lot of teacher intervention, and it didn't enable students to complete the task in a fully independent manner. The container, in which the material that would be poured stayed, wasn't big enough to hold at least 5 cups or salt shakers. In addition, the teachers had to reposition the container after each time because the previous solution only automated the pouring part. Our goal was to make this task as easy, accessible, independent, and student-centered as possible.

To address these limitations, we developed EasyPour, which is a switch-activated dispensing system created specifically to cater to students with various limited physical abilities. Our final prototype includes a powered auger dispensing system and a rotating lazy susan baseplate, which are both powered by different stepper motors. In addition, EasyPour is activated by two switches, one controlling the dispensing and the other controlling the rotation. On top of the auger, we have a large container that can hold up to 10 cups. With these improvements, we were able to solve the teacher intervention problem in both aspects, refilling the container and changing the cup underneath the dispenser.

Throughout the ideation and building process, our team focused on several key design aspects: accessibility, safety, ease of use, affordability, and durability. In addition, we added features such as a removable container for easy maintenance; an auger for accurate dispensing; a clear dispensing tube for visual stimulation; and a funnel to ensure dispensing without spilling.

This process also highlighted the importance of inclusive engineering and design thinking. For an ordinary person, these tasks might seem very simple, but they can also be big milestones for people who were never able to complete them before. The emphasizing aspect, when merged with engineering principles, creates tools of empowerment, independence, and integration. With this in mind, we designed EasyPour to have 2 switches to make it a group activity. This way, people using our solution can both socialize, be satisfied by their actions, and share this milestone with a friend.

Even though our current prototype meets the requirements, there are opportunities for future development. Potential improvements include liquid integration, precision pouring, incorporating food-safe materials, and putting a multiple-compartment container on top to store different kinds of granular material at the same time. These additions could reduce teacher assistance even further while increasing the different kinds of activities our solution supports.

Despite limitations including time, manufacturing scale, and experience, EasyPour creates a strong foundation for improvement. EasyPour also caters to the Park School's mission of promoting independence and hands-on quality education. We combined accessibility-oriented

engineering with practical needs and created a solution that isn't just a machine but a representation of a meaningful endeavor towards a more inclusive and accessible future.

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Appendices

Appendix A: Project Definition

Project Definition: v3.2

Project Name: Switch-Activated Automated Dispenser

Project Partner: Jennifer Flaxman

Team Members: Max Kaung, Duru Akpolat, Brady Chiu, Bryce Warner

Date: 5/26/2026

Version: 3.2

Mission Statement

To create an automated dispenser system for Park School students who are experiencing physical limitations, aspiring to fulfill their psychological and physical needs

Project Deliverables

- Final report (digital copy)
- Slide presentation during finals week
- Final prototype

Design Constraints

- Budget (\$150)
- Time (One Northwestern Quarter = 12 Weeks)
- Americans with Disabilities Act Design Guidelines

Users and Stakeholders

- Jennifer Flaxman: vocational teacher at Park School, will use the device to perform pouring vocational training
- Teachers/assistants at Park School: help facilitate students pursuing vocational training
- Students at Park School: will use the device to dispense independently via buttons
- Teachers who work with students with limited fine motor skills: help individuals with pouring tasks
- Individuals with limited fine motor skills: want to be able to dispense materials independently

User(s) Profile

Individuals with limited fine motor skills:

Students at Park School with limited fine motor control skills tend to have difficulties lifting and maneuvering heavy objects with precision, such as the act of pouring materials from a pitcher into a small container. Students may want to be able to dispense materials independently, whether for vocational, social, or personal purposes. The use of a button-activated rotating pitcher and a button mount allows them to fill single containers on their own; however, the system's low pitcher volume and capacity for only a single container mean the teachers are required to assist in the pouring process, taking away from the students' independence.

Teachers:

Teachers at Park School use button-activated dispensing systems to teach students vocational skills and independence in pouring tasks. The current system of a rotating pitcher forces teachers to intervene when refilling the pitcher or exchanging the cups, preventing teachers from giving the students more independence.

Illustrative User Scenario:

J.F. begins class at Park School, the day plans to teach Park School's students how to pour each other drinks and snacks. Many of the students are unable to lift a container of water or food on their own, but with well-placed buttons, they can activate devices by pressing buttons with different body parts. J.F. fetches the automatic pitcher, which has been used before, with difficulty, to dispense dirt by slowly rotating the pitcher at the press of a button. Finding it dirty, J.F. carefully cleans the pitcher, fills it with water, places a cup below, and connects one of the students' buttons to the device, all while the students watch for several minutes. J.F. realizes that the purpose of the activity was to show the students how to dispense things independently, and finds it unfortunate that she must complete so much of the process for them. Finally, a student can slowly pour a cup of water, but when they press the button for a second too long, water overflows from the cup, spilling onto the floor. J.F. cleans up, and when the student tells her they want to pour water again, she manually refills the pitcher and switches out the cup for the student. For each student, she carefully monitors their pouring and manually tends to the water and the cups, resulting in tens of minutes spent for each student to fill a few cups of water. J.F. moves on to dispensing granola snacks into small plastic containers. She takes special care to align the small containers perfectly below the pitcher, and when the student pours, the granola clumps up due to leftover dampness on the containers and pours unevenly. After class, the students tell J.F. they wish they could pour more containers on their own, and J.F., exhausted from the tedious process of manually exchanging and refilling, wishes there were some way to give the students a little more independence in the task of dispensing.

Project Requirements

Table 1: Project Requirements for Project Definition v3.2

Needs	Metrics	Units	Ideal Value	Allowable Value
Compatible with switches	Ports	N/A	Switch input jacks for button switch, wall plug for power source	Switch input jacks, wall plug or Powerlink
Powered	Power Source	N/A	Wall outlet	Internal battery or outlet
Enough material capacity to fill multiple containers	Volume	L	2 Based on the standard size for small tanks	0.5 Based on the volume needed to fill 5 cups
Ability to dispense multiple materials	Compatible materials	N/A	Can solids of various sizes, ranging from salt to beans	Can dispense salt and pepper grains
	Solid grain size	mm	Ranging from 0.3 to 10 Based on the grain sizes of salt and beans	Around 0.3 Based on the grain sizes of salt and pepper

Detects when a container is fully filled	Method	N/A	Auto-detected using ultrasound, or programmed in using weight	Programmable using the pouring duration. Adjustable duration via Powerlink or other interface. Includes info on pouring durations
Automatically prepares the next container to be filled	Number of containers	Count	10 Based on half the number of cups in 2 liters and a feasible plate area within 1 ft x 1 ft.	6
Food safe	Material choice	N/A	FDA-approved food-safe and non-porous material	Non-toxic or reactive material
	Cleanability	N/A	Easily disassembled and dishwasher safe	Able to be disassembled for all areas to be cleaned
Portable	Height	in	12 To fit within a cubic foot	16 Based on other devices used by Park School

	Width and Length	in	24 To fit within a cubic foot	18 Based on other devices used by Park School
Engaging, entertaining, and fulfilling use	Design features	N/A	Grants the user a fulfilling sense of having completed a pouring task. Emulates independent pouring	Grants the user an entertaining experience. Uses toy-like components and internal part visualization.

Appendix B: User Observation Summary

Introduction

The purpose of this observation was to gather additional insights about the pouring device we were tasked with designing for our Design Thinking and Communications course. This observation involved visiting the school, interviewing users, examining the current device, the users needs, and understanding where the current setup falls short. This information will inform our design choices so we can create a product that better suits the users needs. An in-person observation also allows us to gain insights we previously couldn't get from online interviews alone.

Research Goal

The goals of this observation are:

- Understand what the primary and secondary users need from a redesigned pouring device
- Understand how the current setup operates and identify shortcomings and areas of improvement
- Inquire about current use cases
- Clarify device requirements
- Observe the current workflow while the device is in operation

Context

The observation was conducted at the Park School in Evanston, IL, a center that works with students with disabilities. One activity that the students engage in is transferring goods from a larger container into a smaller container as a way to build vocational skills. The teacher loads the larger container with a specific substance being used for that one session, such as salt, pepper, or even liquids such as water. The student operates a button that tilts this container so the goods are transferred kinetically into a smaller receiving container.

Although the current setup works, it has limitations. First, the workflow relies on the teacher. The teacher must often refill the container after pouring, and has to supervise the student carefully to prevent spillage. This means that even though the student is capable of pressing the button themselves, they cannot truly perform the pouring action independently. Hence, the school has expressed their wish for a device that reduces the dependence on teachers.

Methodology

Location, Attendees, and Time

The interview was conducted on April 16, 2026, at the Park School in Evanston IL. One member from each of four DTC groups was present, as well as Susanne Malarkey and Jennifer Flaxman, teachers at the Park School.

Research Tools

We used three methods during the visit:

- Interviews
 - We spoke in person with Susanne, one of the teachers at the school
- Observation
 - We were able to see and touch the current device, press the buttons, test how the mechanism worked, and we took notes.
 - We also noted where the device felt awkward to use, or limiting.
- Recording
 - We took photos and videos of the current device and workflow, and recorded interview audio

User Group

During our visit, we didn't interact with any primary users, or observe the pouring activity being performed by both the teacher and the student. We spoke only with the secondary users, the teachers, who are in charge of setting up and monitoring the activity. However, the teachers gave a thorough demonstration of the typical workflow during the activity, even without a student present.

Materials

We brought our phones for taking videos, photos, and audio recordings. We also brought a tape measure for measuring the dimensions of the device and containers currently used.

Summary

Pouring Device

The device contains a measuring cup attached to a horizontal shaft using velcro. This means the cup is easy to remove and clean when necessary. A switch is plugged into one of two ports on the back panel of the device, and pressing the button rotates the shaft. When the cup is attached and the shaft rotates, the cup tilts, allowing goods to pour out via gravitational force. The shaft can also rotate in both directions, depending on which port the button is plugged into.

Furthermore, the speed of the shafts rotation can be controlled via a knob also on the back panel of the device. The back panel is attached via screws and can be removed. During observation, we didn't remove the back panel to avoid causing any damage. However, an imprint on the back panel specified that the device runs on 3 AA batteries.

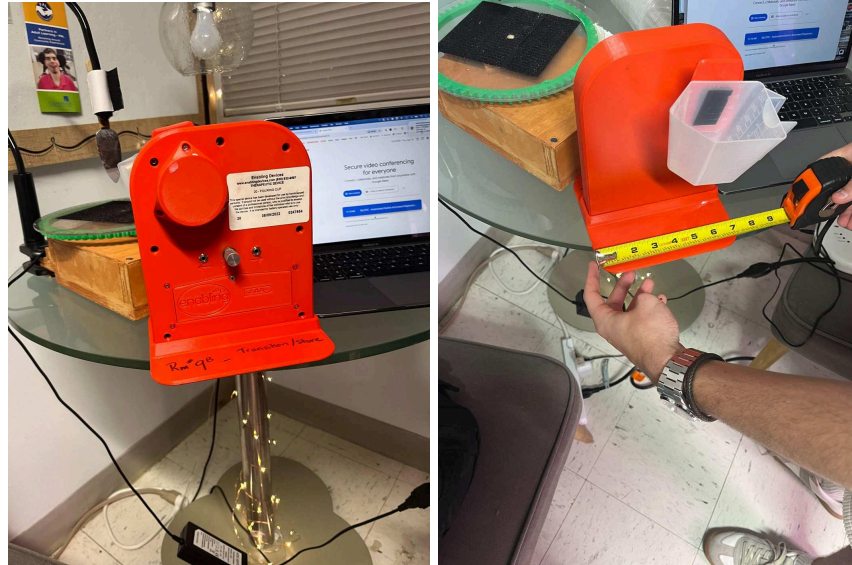


Figure 14: Front and Back Views of Current Pouring Device

Containers

The current device is set stationary on a table, and pours into one container at a time. During sessions, this container will be either a salt/pepper shaker, or a plastic cup. According to the secondary users, our device design only needs to accommodate one of these containers. The teachers are also flexible about what goods go into what container – salt can go into plastic cups, water can go into salt/pepper shakers, and vice versa.

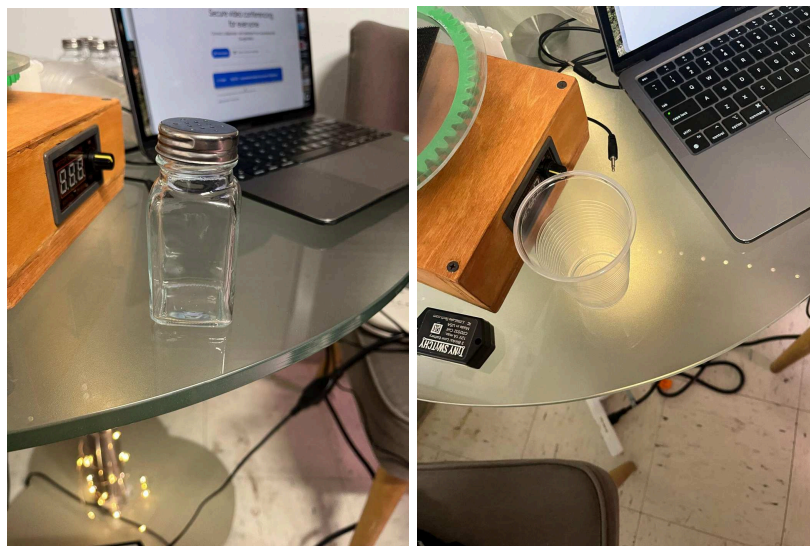


Figure 15: Salt Shakers and Plastic Cups Used by Park School

Tiny Switch

Before connecting into the pouring device, the button can first connect to an intermediary accessory called a tiny switch. The tiny switch allows the teacher to change how the button affects the device. Without the tiny switch, the shaft only turns while the button is held down.

However, according to the teacher, some students cannot continuously hold down the button. The tiny switch, therefore, allows the teacher to convert the button mode into a timer based press, where pressing the button once turns the shaft for a set amount of time. The teacher can easily adjust this time on the tiny switch.



Figure 16: Tiny Switch Used by Park School

Powerlink

The powerlink performs similarly to the tiny switch, however, it allows two buttons to connect to it instead of only one. In addition to the existing hold and timer modes, the powerlink also allows each button to be set to toggle mode, where pressing the button once starts the device, and pressing again stops the device. This means that theoretically, two buttons can each control one different mechanism on a device, for example, one for rotation, and another for dispensing.

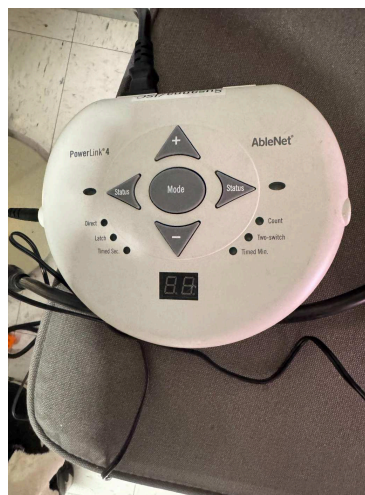


Figure 17: PowerLink Used by Park School

Lazy Susan Style Candle Wax Stirrer

In addition to the pouring activity, the students also engage with a separate mixing activity using another device. This device contains a rotating, circular base plate and a stationary stirrer. When a bowl is placed on the base plate, the stirrer sits inside the bowl. Hence, when the base rotates, whatever is inside the bowl gets stirred. Ms. Flaxman liked this setup, and suggested an ideal pouring device would work similarly: a stationary dispenser above a rotating base with multiple containers, so more containers could be filled without a human swapping them out.

Buttons

According to Ms. Susanne (last name unknown), The Park School also had different types of buttons, with different sizes, colors, and mounting options. During our visit, we only saw the standard, circular red button. The buttons each have a plug that can connect into various devices, including the current pouring device, for operation.

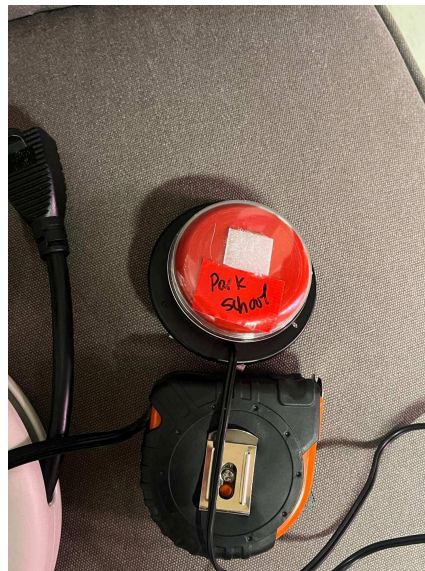


Figure 18: Accessible Red Switch Used by Park School

Analysis and Conclusions

Overall, the visit gave us a clear picture of what the current pouring solution looks like, how its used, and what its limitations are. The main limitation is that it relies too heavily on teacher assistance. Teachers must refill the larger container frequently, swap out the receiving container, and monitor the students closely during the activity. Additionally, without the teacher's intervention, the current mechanism can only tilt in one direction, meaning that if liquids are used, once the container tilts below the horizontal axis, the liquid will continuously flow. Reversing the tilt direction requires the teacher to unplug the button from the forward port, and plug it into the reverse port. This suggests that the students are not truly independently controlling the pouring of goods.

We also observed a few takeaways we could potentially address in our own design. For example, as Ms. Flaxman liked the lazy susan design, we could design a fixed pourer above a rotating base holding multiple containers. Additionally, since we learned that we only need to handle one type of container each session, we can use a single type of holder for holding containers in place. Since the current device accessories (the buttons, tiny switch, and powerlink) work well for both the students and teachers, our design should incorporate these instead of replacing them. Students and teachers are already used to operating different devices using a button. Lastly, the device must handle both dry goods and liquids, depending on what is being used during sessions. This has important implications for our device, as we need to consider the risk of liquids leaking into any electronic components we use.

Limitations

- We didn't see any live sessions between students and teachers doing the pouring activity, so we may have some misunderstandings about how the device performs.
 - We may have also missed key details about operating the device, e.g. how long it's typically used for during one session, which may impact battery life.
- Our visit lasted under two hours, which limited how much we could observe and the number of questions we asked.
- We only spoke with two teachers, which may not fully reflect the full range of perspectives from all teachers about the current device.
- We never opened the back panel of the device to avoid causing damage, so we do not fully understand how it operates.

Appendix C: Preliminary User Testing Summary

Project Partner Interview - Mockup Review

Date: 4/28/26

Time: 3:30-4:10 PM

Location: Ford 2227

Team Members in Attendance: Max Kaung, Bryce Warner, Duru Akpolat

Other Key Attendees: DTC Section 17 Team 4, other DTC pouring project teams, J.F.

Objective:

1. Obtain J.F.'s thoughts on our initial ideas/mockups
2. Obtain more specific information on the project requirements

Testing conditions

- Displayed mockups over a Zoom meeting near the webcam
- Groups were seated around a long conference table in a well-lit DTC conference room

Testing session overview

1. J.F. was asked several questions about various project requirements
2. J.F. was given an overview of the types of mockups to be presented, including the dispensers and the container holders
3. J.F. was presented with each mockup, including a short description and demonstration of its function
4. J.F. gave her opinion and other comments on each mockup, as well as clarified relevant project requirements

User overview

Jennifer Flaxman, a vocational teacher at Park School, will use the device to perform pouring vocational training

User Feedback

Our mockups are separated into the different key mechanisms of our current solution. These mockups include the:

1. Auger dispensing system
2. Dispenser stand
3. Lazy susan cup holder.



Figure 19: Mockup One, Auger-Dispensing System

Figure 19 shows how granular material enters through the funnel on the left, and by rotating the screw via the rod, the material is moved laterally and dispenses out the bottom of the tube.

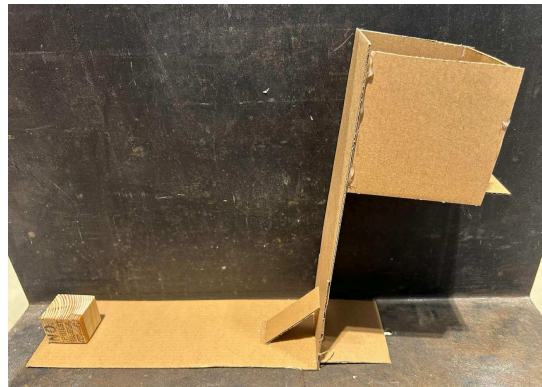


Figure 20: Mockup Two, Stand to Elevate Dispenser

Figure 20 shows how the stand uses a wooden counterweight and can dispense items from the box via a sliding panel.

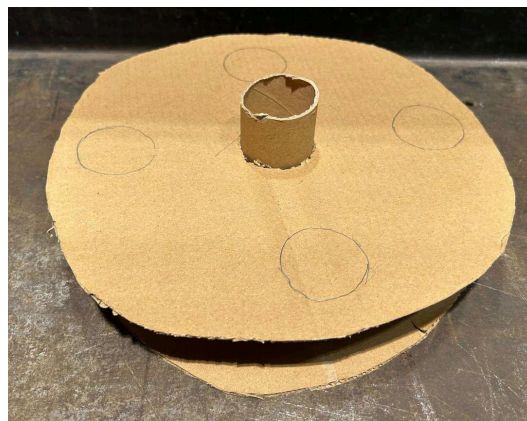


Figure 21: Mockup Three, a Lazy Susan to Hold Cups

Figure 21 shows how cups or containers can be placed on the top panel and are rotated around on top of bearings.

Below is a table showing the mockups our team demonstrated, as well as the feedback given by Jennifer Flaxman:

Table 2: Mockup Questions and Feedback

Design	Question	Answers/Commentary
Auger Dispensing System	Should the dispenser feel like it's physically pouring? Should the dispenser continuously dispense while a button is pressed or complete a full dispensing task after a single press? Does the dispenser need to detect when the container is full? Are there any other comments or concerns with the auger dispenser?	• Dispensing is allowed; the priority is not to have to refill frequently • Granular dispensing is preferred, but liquid dispensing would be great • One powerlink can control 2 different switches • At least 5 containers should be able to be filled in a single sitting (before refill or container replacement) • Weight is not a big constraint, should be relatively portable, shouldn't be too big • Filling it with a single switch would be nice, but 2 switches are fine • Typically, the instructor does the testing and can confirm whether it would work
Dispenser Stand	Does the dispenser stand have any weight or size requirements? Are there any comments or concerns with the dispenser stand?	
Lazy Susan Cup Holder	How many containers should the lazy susan have the capacity to hold? Are there any comments or concerns with the lazy susan?	

Analysis and Implications

- The current auger system is functional, along with a lazy susan base plate for rotating through containers. Materials and tolerances should be researched for the auger and auger

tube. Additionally, systems for preventing clogging from the tank to the auger should be included in the final design. Microcontrollers and wiring should be planned out for the controlled motion of the lazy susan, keeping in mind the connection to the powerlink.

- The primary project requirements to design around, considering the time constraints, are: the ability to dispense salt and pepper, the ability to complete a full dispensing task with one button press, the ability to automatically switch containers with a separate button press, the ability to stop dispensing when a container is filled, and a size profile able to be easily carried and transported in a car.

Appendix D: Final User Testing Summary

Date: 06/01/2026

Time: 2:30-2:50 PM

Location: Ford Mechatronics Lab

Team Members in Attendance: Max Kaung, Bryce Warner, Brady Chiu

Other Key Attendees: Jennifer Flaxman

Objective:

1. Obtain Jennifer Flaxman's thoughts on our final prototype
2. Clarify any questions Jennifer Flaxman (J.F.) has about the prototype

Testing Conditions

- Displayed final design over a Zoom meeting near the webcam
- Connected device to a power outlet in the wall
- Used rice as the granular object
- Used buttons provided by Park School as accessible switches

Testing Session Overview

1. J.F. was asked several questions about the current final prototype
2. J.F. was given an overview of the final design and its individual components
3. J.F. was briefed on the different components and how they work cohesively
4. J.F. watched as the auger and plate both operated, as well as other operations that mimicked the prototype in action
5. J.F. provided her likes towards the prototype and highlighted beneficial aspects
6. J.F. offered her opinion on the final prototype and other comments before the design was completely finalized

User Overview

Jennifer Flaxman is the Transition Coordinator and Teacher of the Deaf and Hard of Hearing at Park School. She will use the device to teach students to pour independently for everyday and vocational use.

Methodology

After completing the final prototype, the design was tested with J.F. to ensure all requirements were met and that the solution would be functioning for Park School students. To ensure the device met the standards for the project, the following methodology was conducted over a virtual meeting:

1. Set up the camera to fully capture the entire device
2. Plug the 12V power adapter into the breadboard
3. Plug the 12V power adapter into the wall, powering the device

4. Plug both corded buttons into each jack on the side of the plate mount to connect the switches
5. Unscrew the cap of the upper container basin
6. Pour rice into the container basin, allowing ~50 ounces of rice to fill the container
7. Place 5 cups onto the lazy Susan plate in each respective indent
8. Press the left button, activating the motor for the auger, which rotates the screw about 7 times
9. Press the right button, activating the motor for the lazy Susan, which rotates the plate 72°
10. Repeat this process four more times to fill each cup with rice, ending with 5 independently filled cups

User Feedback

Our final prototype contains two main mechanisms that we desired feedback on. These two main mechanisms are:

1. The rotating lazy Susan plate
2. The rotating auger

J.F. offered little feedback on the device itself, but asked questions about its operation, design choices, and other aspects. Below is a table with those questions, as well as the answers, a discussion of the question, and any demonstrations provided for her:

Table 3: Final User Feedback Questions and Discussions

Question	Answer	Discussion	Demonstration
Is it able to be cleaned?	Yes	The motor is screwed to the back of the mount by four screws. By unscrewing this, the screw and the vinyl tubing can both be cleaned.	We unscrewed the back motor and showed how it is simple to deconstruct the auger component.
Can you activate both mechanisms at the same time?	No	The motors were coded to only be activated both one at a time. You cannot dispense and rotate the plate at the same	Demonstrated us pressing both buttons after one was pressed with no actions occurring.

		time.	
Can we change the number of inserts or the number of plate rotations?	Somewhat	The baseplate is 3-D printed, and the breadboard is coded for only 5 cups. The motor can be reprogrammed, however, and the plate can be reprinted.	We showed her the preset inserts for the baseplate as well as explained how we coded the motor.
Does the auger automatically dispense the correct amount? Does it have to be pressed multiple times?	Yes, does not have to be pressed multiple times	The auger will spin around seven times to fill the cup. It makes an auditory cue that it is done filling, as well as visually seeing the auger complete spinning.	We pressed the auger activator once and watched as it spun seven times.
How many times does the student need to click the buttons?	Once	Each button only needs to be pressed once to complete a full action.	We showed her pressing each button once to complete one action.
Can the switches be interchanged?	Yes	There are two basic jacks on each side of the base for the plate. These can be interchanged for other switches.	We showed her the two jacks on the side plugged into the breadboard.
What should I do if there are any issues with it?	Contact us	If there are problems with the electronics or motor, she can email us, and we will solve it.	We showed her the breadboard and the electronics, showing that they are attached more permanently and will be difficult to take apart.
Is it food-safe?	No	The device is not food-safe. Because we did not use a food-safe printer that uses PLA plastic, we would not	N/A

		recommend that you eat the materials placed in the dispenser.	
What if it gets clogged?	It can be disassembled	The device can be disassembled if it's clogged. As shown before, the auger and the tube can be removed if the motor cannot spin and granular objects get stuck. If the objects become clogged from the top, it can	The back of the motor was removed when rice was inside the auger, unclogging it. We also showed that if the granular objects get stuck in the funnel into the auger, it can be unclogged by sticking a pencil-like object into the top.
Will it spill?	No.	There is a small pointed funnel underneath the auger that allows for more precise dispensing without letting the auger clog.	We showed her the funnel and its attachment to the device.

Analysis and Implications

Based on the final prototype view with J.F., the device appears to meet the main goal of the project: increasing independence amongst Park School students completing a pouring task. The rotating Lazy Susan and auger dispenser cohesively work to allow students to fill multiple cups using accessible switches, rather than depending on teachers to refill, reposition, and reset the device after every use. This increase in independence directly supports our team's focus on student independence and reduced teacher involvement. The prototype's biggest successes are its accessibility and its repeatability. Each button only needs one click to activate, making the device easier for students with limited fine motor skills to utilize for everyday tasks. Furthermore, because the device requires two inputs, it opens the possibility for collaboration amongst students to complete pouring tasks together. Both of these inputs are interchangeable, meaning that depending on a student's ability, different types of switches can be used to best work for each unique user. Furthermore, we noticed very little spilling due to the funnel, which can greatly decrease teacher intervention as they do not have clean spills of rice, salt, or beans.

While we noticed many successes, the device still has limitations that should be considered for classroom use. First, the prototype is not food-safe, so it should be a supervised activity to prevent any of the materials from being ingested, as the materials used are not inherently food-safe. This applies to the manufacturing methods as well, considering we used non-food-safe 3-D printers. Second, the device is designed around a fixed number of containers and programmed to operate based on rotation angle, meaning that Park School cannot alter the device itself. If Park School hypothetically wanted to increase the number of cups the plate holds and increase its rotations, it would require reprinting parts and reprogramming the motors, which can only be done by our team or a knowledgeable person in programming and CAD, making the device dependent on our team. This further applies to motor issues or fixes to the prototype, as it is unlikely to be fixed by our project partner. Lastly, the auger works with rice, but other materials may flow differently and clog the auger or dispense inconsistently, which can damage the independence aspects of the device.

Overall, the final prototype is successful as an accessible pouring device for dry granular goods. It offers students a more active role in an everyday process and reduces input and assistance from Park School teachers. To improve the device in the future, food safety, easier adjustability, stronger clog prevention, and compatibility across all materials should be implemented for better results for use.

Appendix E: Secondary Research Summaries

Automated Systems Research

Introduction

Park School in Evanston, Illinois, through its collaboration with Northwestern University's Design Thinking & Communication programs, aims to improve everyday and vocational training experiences for students with varying disabilities between the ages of 8 and 22. One task students often encounter is dispensing granular materials such as salt, rice, and beans into containers. Current technology at Park School allows students to activate a mechanism that tilts a measuring cup and pours a material into another container using an accessible switch. However, this system requires teacher intervention to load materials into the measuring cup, refill the device, and reposition a singular container after each use.

This necessary outside support creates a gap between being able to activate something and being able to complete a task independently. Although Park School students can press a switch or button, the task of pouring is not fully independent, as many steps rely on outside assistance. Since many students at Park School have limited fine motor skills and rely on switch-based assistive devices, mechanically simple tasks can become more difficult when it requires grasping, timing, pouring, or physically adjusting.

The goal of this research is to understand automated control systems, dispensing mechanisms, and assistive technology design to see how an accessible dispensing device could improve independence amongst students. Automated systems show how inputs, controllers, actuators, and feedback can reduce repeated human intervention, while differing dispensing technologies, such as solenoid valves, auger feeders, and compartment-based machines, show how different materials can be dispensed in varying amounts. Furthermore, assistive technology research is as important because accessibility surrounding this project is not whether a user can press a button, but if the system reduces the amount of physical exertion by students and teachers, as well as reduces teacher assistance in loading and moving containers.

Automated Systems Fundamentals

Automated systems operate through a basic sequence where an input is received, processed by a controller, and translated into a physical action by an actuator. For Park School's dispenser, the input could be a student pressing an accessible switch. The controller would interpret the signal, and the actuator could then rotate a lazy-susan platform, open a valve, or activate a motorized auger. Carey describes how automated systems can reduce human involvement by having the actuator complete an action rather than someone physically completing the task themselves, while Bennett explains how automatic machines regulating outputs instead of completing fixed actions can tailor systems to complete a certain task, such as filling a container with salt without overfilling it [1], [2].

The current technology at Park School acts more like a simple open-loop system. Once the student activates the switch, the device performs one motion, but it does not know if the correct amount was dispensed, if the container is full, or if the next container is ready to be filled. In an open-loop system, feedback compares what is happening with what should be happening, allowing the system to adjust, slow down, or stop if needed [3]. For example, a dispenser with a weight sensor could stop once the correct mass of rice has been released, while a salt dispenser could use time, volume, or weight feedback to stop before it overfills.

For Park School, feedback is not only a technical feature but an accessibility feature. A motorized pouring mechanism can reduce physical exertion, but students pouring still have teachers to stop the machine, reset it, and clean up spills; the students are not completing the full task independently. A closed-loop system would better address the current issues of refilling, repositioning, and spilling, as it would shift the monitoring and input from the teacher to the device itself. This would allow students to participate more directly and independently in the full dispensing process.

Dispensing Mechanisms

Automated dispensing systems use different mechanisms depending on the material being dispensed. This is important for Park School because the device will need to dispense varying granular goods, ranging from salt grains to beans. These materials behave differently, so one mechanism will not necessarily perform optimally for all materials.

For dry goods, gravity-fed dispensers and auger-based systems are most optimal for changing materials. Gravity-fed dispensers are simple because they allow material to fall downward through an opening. However, they can be unreliable as materials flow differently depending on particle size, friction, and cohesion [4], [6]. This is a prominent issue for Park School because salt, rice, and beans will not move the same way through openings or dispensers. Salt may flow too quickly, while beans may jam a small opening, making dispensing mechanisms important to understand, as increased clogging risk will decrease students' independence and force teachers to intervene with the machines.

Auger dispensers provide greater control because they use a rotating screw to advance material. Screw feeders are commonly used for powders, grains, and other bulk materials because the screw speed and shape can regulate flow rate [6], [12]. Research on bulk-solid and powder feeders shows that feeder accuracy largely depends on the material, hopper shape, and refilling mechanism [5]. This mechanism applies directly to Park School's problem because the device will handle various materials with varying flow characteristics.

Assistive Technology and User Interaction

Assistive technology is most useful for helping a user complete an entire task rather than a single

movement. Switches are often used because they can be easily accessed by different parts of the body, including the hand, head, leg, or chin. This makes them crucial for students with limited fine motor skills. Switches, however, cannot create independence alone. If a student can press a switch but a teacher still needs to load the material, place the container, monitor the poured amount, and reset the entire device, then the system is only partially accessible.

Assistive device control research emphasizes that accessible systems consider reliability, physical exertion, safety, positioning, and the number of required actions from the user [8], [11]. Ding describes integrated control as a way to connect multiple assistive device functions together through a single, more accessible control system [8]. This concept directly applies to the dispensing problem, as the current system allows a student to activate one mechanism, but it does not connect the other necessary steps for independent dispensing. The design should reduce the number of separate actions required from both the student and the teacher, which should be done through the fewest number of switches possible.

Alternative-access research also shows that input methods should match the user's motor abilities and their daily environment, rather than being treated as universal solutions [10], [11]. For Park School, this means the switch should not require precise timing, repeated pressing, or holding switches down unless those actions are realistic for the student. From this research, a single press that activates an automated sequence would be more accessible than a system where a student has to manually stop the device at a precise moment.

Feedback is also important for the user. The student should be able to tell when the mechanism has started, when the container is being dispensed, and when the mechanism is complete. This feedback should be visual, auditory, or tactile, depending on a student's ability. Indications of the mechanism being complete could be a light, sound, or vibration to show when the container is in place, the material is dispensing, and when the entire mechanism is complete. This would make the device more accessible as students are able to determine when different mechanisms are complete, allowing for better comprehension of the device.

For this project, the most accessible solution would combine up to two inputs with an automated task sequence. The student could press one switch to position the container, with the user being notified it is in place, and when the next switch is pressed, a controlled amount is dispensed and stops automatically with a signaled completion. This would better support independence as it reduces physical effort by students and teacher intervention.

Similar Solutions and Technology

Existing dispensing systems show that control and accessibility are often separated. Industrial dispensing systems are designed for accuracy, speed, and repeatability with little adaptation for accessibility through extensions such as switch access. Assistive switches make activation easier, but they are intended to control one action at a time. Park School's difficulties with the current

solution sit between the need to dispense accurately while allowing participants with limited fine motor skills to act independently. To better understand how automated dispensing systems can solve Park School's problem, it is beneficial to understand how existing solutions control material flow automatically and if there is room for accessibility.

One relevant example is the feed-wheel sugar dispenser, which uses a rotating disk with fixed compartments to dispense predetermined quantities of material, with the material being able to vary as compartments are varied. Each actuation advances the wheel, aligning with one compartment that has an outlet, releasing a controlled amount. While this system is not automated, it provides insight into how multiple materials can be integrated into the solution and dispense solid materials [7]. Further, it shows how consistent portions can be achieved mechanically, as there are no sensors, but it would require manual input and does not support accessible sensing.

Automatic pet feeders provide another useful example. These devices use motor-driven mechanisms to release a set amount of compartmentalized food based on a programmed schedule or user input [4]. These feeders show how repetitive dispensing can be automated, but they do not fully solve Park School's problem because they are often designed for one material, one container, and limited user input; they do not address accessible setup or container movement, but they show repetitive dispensing from an attached container.

Bulk-solid feeders, including auger feeders and loss-in-weight feeders, are useful examples for granular materials. Auger feeders are motorized screws that rotate to transport and dispense materials, often on farms for feeding livestock. Loss-in-weight feeders measure how much material leaves the feeder over time, allowing the machine to dispense accurate amounts repeatedly. These systems can control powders, grains, and other solids, but their accuracy depends on material flow, hopper design, and their refilling conditions [12]-[14]. Because the materials Park School plans to dispense vary in size and flow, the dry dispenser should have a flexible design that dispenses different materials without clogging or overflowing.

A rotating "lazy susan" platform could solve a different part of the problem, being container positioning. Instead of requiring a teacher to replace each container after filling by hanging, a motorized rotating platform could bring the correct container beneath the dispenser. This would be useful for the device dispensing multiple times during one activity. When combined with an automated dispenser, the platform would improve the pouring action for students, as they can fill multiple containers without intervention.

The strongest design direction is not a copy of an existing product, but a combination of multiple existing technologies. Park School's dispensing device could have an auger or compartment wheel for dispensing dry goods, a rotating platform for repetition and positioning, and sensors

for active feedback. This allows for accessible control, making the design understandable and accessible for students.

Conclusion

Current automated dispensing systems offer precision and repetition, but most are not designed around accessibility. Assistive switches make device activation easier, but they cannot make the pouring tasks fully independent for students. Park School's current system shows this as students can activate a switch, but teachers and aides still have to load materials, refill the device, reposition the containers, and monitor for issues.

A more effective solution should combine automated dispensing technology with an accessible design. For dry goods, auger feeders or compartment-based mechanisms could improve portioning for containers, while a rotating platform could reduce the need for manual container repositioning. These two mechanisms, along with feedback sensors, would help prevent spilling or overfilling and make the task fully independent of the position of the dispensing. By connecting these technologies into two accessible sequences with an accessible switch controlling the plate mechanism and another controlling the dispensing tasks, students could complete more of the dispensing tasks independently.

The main design challenge is not making a cup pour automatically, but creating a system that reduces assistance surrounding the task. A successful device would support Park School's vocational and daily training goals by improving independence, reducing teacher intervention, and giving students a more active role in completing everyday dispensing activities.

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Accessible Learning Research

Introduction

According to the Bureau of Labor Statistics, in 2025, the employment rate for people with disabilities was merely 22.8%, compared to 65.2% for those without [1]. These figures highlight the harsh employment gap that the disabled community faces today. Even though there have been efforts to close this gap, their impact has been insufficient. For example, a 500-million-dollar federal program (Pre-Employment Transition Services) designed to prepare disabled students for the workforce only reached around 300,000 students, even though 3.1 million were eligible. This lack of support leaves disabled students struggling to perform in the workplace. The Hechinger Report details one instance in 2025 where a student with an anxiety-related disability quit his trucking job despite being qualified for the role. He resigned because the anxiety of working on call caused him to lose several nights of sleep in a row. Because he never received any pre-employment training, he was unaware that he could request the proper accommodation he needed for his job [2]. Thankfully, there may be a solution. Years of research have shown how Assistive Technology (AT) - devices that aid people in performing tasks - helps disabled students develop the independence they need instead of relying on others. This report examines how AT builds independence through situated learning, scaffolding/fading, and self-efficacy.

Situated Learning

Situated learning refers to the idea that skills are easier to master when learned and practiced in the real world. For example, even though a driving student may excel on a training track, it's not until they navigate real traffic that their driving skills really improve. In a 2019 study involving 13 teachers working with disabled students, the teachers described the classroom as a “faux” environment. In other words, they believed the classroom was not similar enough to the real world for their students to truly learn any skills. 2 teachers stated that they believed a student had only learned a skill if they could perform it in the real world [3].

However, research suggests that AT can bridge the gap between the classroom and the real world. A 2024 meta-analysis of eighteen studies found that technology such as virtual reality, training simulations, etc, could help students better develop real-world vocational skills while inside the classroom [4]. For instance, in one study, disabled students practiced cleaning a hostel while in the classroom through a 3D simulation. After learning the required skills, they were able to walk into a real hostel and perform the same task successfully [5].

Other AT studies have demonstrated equal success with virtual reality. One study set up a kitchen in virtual reality and taught students how to cook a meal inside it. Afterwards, the students were able to apply these skills in a real kitchen and cook the same meal with 60% independence [6].

The aforementioned studies highlight a key relationship between assistive technology and situated learning. Although there exists a valid concern that classroom learning may not translate into real-world skills, developments in assistive technology may help close this gap. By better mimicking a real-world environment that classrooms cannot, AT can give students the independence they need to perform tasks in the workplace.

Scaffolding and Fading

While situated learning focuses on a student's learning environment, scaffolding focuses on the amount of support they receive. This concept was formally introduced in 1930 by Lev Vygotsky, when he introduced the concept of the Zone of Proximal Development (ZPD). ZPD refers to the range of tasks that a student cannot yet complete alone, but can with a bit of help. According to Vygotsky, students learn more effectively when they are completing tasks within this range [7]. "Scaffolding" refers to the actions taken to keep students within this range.

Scaffolding is commonly done through a framework known as the System of Least Prompts (SLP). A 2018 report from What Works Clearinghouse (U.S. Department of Education) elucidates this system. A teacher first requests a task, and if the student cannot complete the task, then the teacher gives the least amount of assistance possible. They increase their assistance, or "scaffolds," until the student can proceed [8]. The goal is that the teacher can give a decreasing amount of guidance, "fading," as the student becomes more independent.

While scaffolding is effective in theory, in the real world, it's rarely done properly: teachers often scaffold too early and frequently, causing students to overly rely on them. Hence, educators turn to assistive technology, which may better help them judge when to provide students with the appropriate guidance. To that end, one study in the What Works Clearinghouse report found that disabled students were able to perform office tasks such as organizing binders when assisted by iPhone prompts. Unlike humans, who may give too much or too little help, the iPhone prompts gave the same level of support each time the student requested it, enabling the students to learn the necessary skills.

Bennett and Barbara (2019) further bolster the effectiveness of AT in scaffolding. In their 2019 study, tasked young adults with disabilities with finding grocery items, equipping them each with an iPad as a scaffold. Human guidance was only provided when the iPad prompts were not enough. The study found that many of the participants were able to complete most of the tasks prompted by the iPad [9].

The current research highlights a key benefit of AT in learning. Although teachers understand how ZBT works, they find it difficult to provide the optimal amount of scaffolding and fading. By moving this task to AT instead, instruction becomes more objective and consistent. This

allows students to gain the independence they need, whereas previously, they may have overrelied on human guidance.

Self-Efficacy and Repetition

According to famed psychologist Albert Bandura, whether a student is able to succeed at a task largely depends on whether they believe they even can. This belief is known as self-efficacy, and Bandura argues the best way to build it is to let students do the actual task and succeed. This enables students to prove to themselves that they are capable of succeeding [10].

Artino (2012) bolsters Bandura's claim, identifying a meta-analysis of 100 studies testing nine psychological factors contributing to the success of college students. The studies found that self-efficacy was the most important factor. The idea is clear – instead of simply teaching students how to perform a task, allow the student to perform the task themselves and realize that they are capable of succeeding [11].

Li and Goh (2011) reinforce the idea of self-efficacy, and also go one step further, detailing that it holds specifically for students with intellectual disabilities. They studied 47 students in Singapore with IQs between 50 and 70, assessing how ready each student was for a job and collecting factors such as age, gender, and work experience. The results were shocking – self-efficacy was the most important predictor of job readiness [12]. These findings challenge the common notion that job readiness depends mostly on factors such as ability and experience. In other words, what's important is whether a student believes themselves that they are capable of completing a given task.

Although Artino, Li, and Go establish the importance of self-efficacy, they do not address how students can achieve enough mastery to reach it. According to a medically reviewed publication, mentalhealth.com, students with intellectual disabilities require more repetition than their peers when it comes to building mastery. Specifically, these students benefit the most from repetitive, hands-on practice with immediate feedback. By repeatedly practicing new skills and receiving immediate feedback, students can better build the mastery required to achieve self-efficacy [13].

Hence, while research has demonstrated that self-efficacy is the strongest predictor of job readiness for students with intellectual disabilities, it can only be built when students are capable of succeeding at a given task. In order for students with disabilities to best achieve this success, they should repeatedly train the given skill while receiving immediate feedback.

Conclusion

The concepts of situated learning, scaffolding and fading, and self-efficacy and repetition each provide a different perspective of how students with disabilities can learn new skills most

effectively. The aforementioned studies assert that skills are best learned when the student is in a workplace environment, when they receive just the right amount of guidance, and when they themselves believe they are capable of completing a task. If vocational programs consider all three lenses, they can help students learn skills more effectively, ensure the skills stick, and prepare students to use them in the real world.

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Food Safe Design Research

Introduction

This section summarizes all secondary research on food-safe design and materials, and provides key data and considerations for ensuring a design can safely interact with food. One of the primary criteria for the switch-activated dispensing project is the ability to dispense various food items, whether it be salt for vocational training or beverages for social events. For any product in contact with food, food safety becomes a key consideration, even if the product will not be sold commercially. Within the context of the product being a switch-activated dispenser for students with low-incidence disabilities, the following research covers relevant food safety standards, mechanics of chemical leaching, health impacts, and considerations with 3D printed food contact parts.

This research aims to answer the following key questions:

- What are the relevant food safety standards?
- What are some common certified food-safe materials?
- How do chemicals move from the container to the food, and how can that transfer be minimized?
- What are the health impacts of consuming leached plastic and chemicals?
- What are some considerations, material or otherwise, for food-safe 3D printed parts?

Methods

- Databases: Northwestern University Library, ProQuest, Google Scholar, NSF/ANSI, FDA, Nexus Uni
- Keywords: Food safety, food safety standard, food safe, food contact, food contact material, food safe material, container, plastic, health, 3D print
- Number of sources: 9

Results

Food Standards

If the final product is to be sold commercially, it will likely need to pass standards for food safety, necessitating the need to become familiar with the relevant food safety standards. Additionally, food safety's importance is of practical importance, extending past simply satisfying standards, and researching those standards will provide several key ideas and considerations to guide the development of the product.

In the context of a container to hold food items, there are 3 primary food safety standards to consider: NSF/ANSI 2, NSF/ANSI 51, and FDA 21 CFR.

The first is NSF/ANSI 2, which governs regulations on food handling equipment. This applies to large cooking devices found at restaurants, such as fryers and grills, but also includes “bakery, cafeteria, kitchen, and pantry units and other handling and processing equipment like tables and

components, counters, tableware, hoods, shelves, and sinks, among others” [1, p. 1]. It should be noted that in addition to requirements on materials, NSF\ANSI 2 also covers design features such as rounded corners, latches\hinges, and the cleanability of the product and its individual parts. The safety and sanitation of the product and the food used with the product “is assured at many levels, even that of the manufacturer” [1, p. 1].

Next, NSF/ANSI 51 governs food equipment materials, overall to ensure that a product will not “impart deleterious substances to food in its intended end use application” [2, p. 1]. The standard covers a range of material-related considerations, including the specific material used, its finish, its coating, as well as its resistance to heat, corrosion, abrasion, and impact. This standard is applied to various cooking and food contact products, such as pots, pans, broilers, cutting boards, and even tubing and valve components in contact with food [2].

Lastly, the FDA 21 CFR provides a comprehensive list of FDA-regulated food contact materials. The database serves as a reference point to check for any special regulations on a material [3]. Generally, inert, non-toxic, non-porous, durable materials are fit for food, including stainless steels, glass, silicone, aluminum, lead-free ceramics, and plastics like PET, HDPE, LDPE, polypropylene, and polystyrene.

Chemical Migration

Chemical migration is the movement of particles and chemicals from the material surrounding a food or liquid into the food itself. Chemical migration occurs with nearly all materials over long periods of time, but if the migrated material is toxic or the buildup of chemicals is large, consuming the food can have negative health effects [5][6].

Ultimately, chemical migration is generally understood as being due to microscopic diffusion processes between the food and the packaging material. Many sources agree on the main factors that contribute to the rate and severity of the migration: the composition of the packaging material, the nature and extent of contact, the nature of the food, the temperature of contact, the duration of contact, and the mobility of chemicals in the packaging [4][6]. The composition of the packaging refers to the concentration of the migrating chemical in the packaging. With a greater chemical concentration, the rate of that chemical’s migration will naturally be larger. This also includes the permeability of the packaging material, with more permeable materials allowing chemicals from the outside to also migrate in [4], as shown in Figure 1. The nature of the contact refers to the surface area of contact, as well as any barrier layers preventing contact. Compared to solids, the area of contact with a liquid is higher, leading to greater migration. Conversely, with a barrier layer, such as in multilaminate packaging, the migration can be significantly slowed and reduced [4]. The nature of the food refers to the aggressiveness of the chemicals in the food, as well as the compatibility and solubility of the packaging with the food. More aggressive foods, such as carbonated drinks, can attack the packaging or even cause

corrosion, increasing the rate of migration [4]. The sources show that the rate of migration stems from many factors in both the food and the packaging, and with mostly granular dry solids, the main concern is the chemical composition of the packaging.

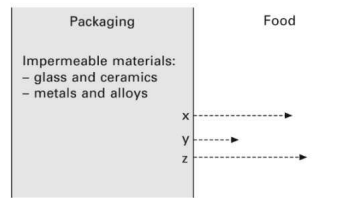


Fig. 1.1 Depiction of chemical migration from an impermeable material.

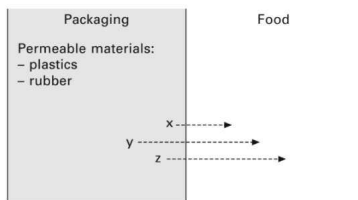


Fig. 1.2 Depiction of chemical migration from a permeable material.

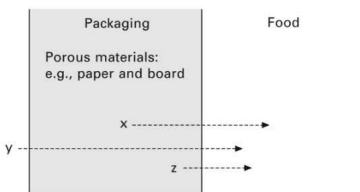


Fig. 1.3 Depiction of chemical migration from and through a porous material.

Figure 1: Diagrams representing the three levels of materials, impermeable, permeable, and porous, and the migration of chemicals within those materials [4].

Health Concerns

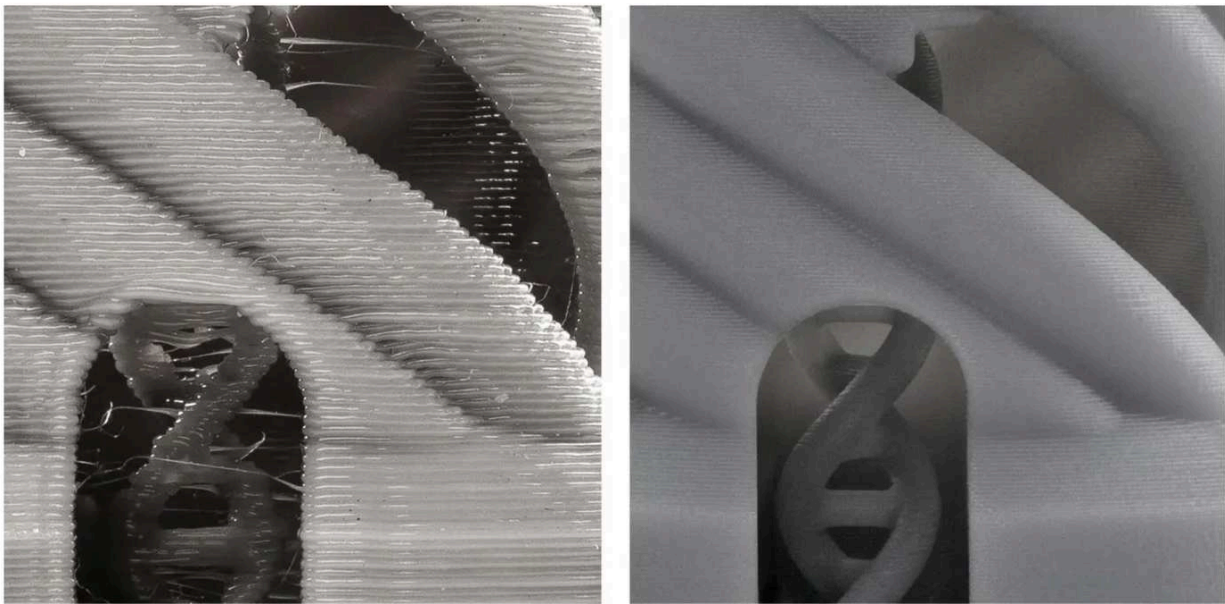
For many toxic chemicals that could potentially migrate into food, the corresponding negative health effects are well known, and materials with those toxic chemicals should be avoided altogether. However, for many plastics, the direct health effects are still an active field of research. While research on the effects of consuming plastic chemicals and microplastics is very limited, research has been conducted on the effects of “plastic-related substances, such as BPA,” which have been “shown to be dangerous at low doses in young children, with carcinogenic and endocrine disrupting potential in adults” [7, p. 5].

Food Safe 3D Printing

Considering the scope of the project, it’s likely that 3D printed parts will be used for prototyping and even the final product due to their ease and speed of manufacturing. Northwestern Segal Institute uses Bambu Labs X1C printers with primarily PLA filament, and standard PLA is considered food safe. Some other common food-safe 3D filament materials are PETG, ABS, and TPU. Unfortunately, creating food-safe 3D printed parts is more complex than using food-safe

material. Stratasys and Formlabs created guides for printing food-safe parts, and the main concerns that were covered include the layer lines and porosity of 3D prints, the potentially toxic composition of the nozzle, and the print's ability to handle heat and washing [8][9].

Firstly, 3D printing creates objects by building them layer by layer; however, this creates small crevices between the layers, which promotes bacterial growth. These layer lines can be reduced in several ways, such as decreasing the layer height during printing or printing with stereolithography as opposed to FDM, which generally allows for much finer detail and smoother layer lines, as shown in Figure 2. Additionally, food-safe coatings can be applied to the surface of the print to seal the surface and create a nonporous shell.



Layers showing on FDM (left) and SLA (right) 3D prints.

Figure 2: Comparison of the level of detail and smoothness of layer lines for a part printed using FDM vs SLA [8].

The material of the nozzle also poses a risk for food contact 3D printed parts. Some nozzles are made with heavy metals and can leach dangerous chemicals such as lead into the parts.

Lastly, the part's ability to handle heat and washing is often difficult to achieve with 3D printing. When using a 3D printed food contact part, it should either be made from a material or use a coating that is dishwasher safe and heat resistant, or simply be designed not to be frequently washed [8]. Both Stratasys and Formlabs highlight that 3D printed food-safe designs are possible, especially with extra processing, but many precautions to prevent harmful chemicals and bacteria growth need to be taken.

Analysis, Conclusions, and Recommendations

Analysis

This research primarily focused on the key considerations in designing food-safe products, rather than on offering existing solutions. In the context of the project constraints, food standards are difficult to meet for commercial use; however, they still provide important guidelines to improve the food safety of a product. Namely, the product should be designed for easy disassembly and cleaning, with rounded edges, and with corrosion/heat-resistant materials. Additionally, research on chemical migration allows for designs that can target and reduce the main factors in migration. Considering the materials to be dispensed, liquid contact with the dispenser poses the greatest risk for chemical migration. This can potentially be reduced through the use of barrier layers or by limiting the duration of contact of the liquid with more permeable materials in the dispenser. This research also presented critical background knowledge on creating food-safe 3D printed parts, requiring that the print nozzle does not contain lead, and offering potential solutions to bacterial growth in 3D printed parts, such as applying food-safe coatings or printing with SLA.

Key Conclusions and Recommendations

- Prioritize design that promotes disassembly and cleanable components.
- Consider the conditions that the product will experience when selecting materials, such as heat, washing, impact, and aggressive liquids.
- Coatings and barrier layers may be effective solutions to ensure food safety and reduce chemical migration.
- 3D printed parts are likely not fully food safe, even if they use food-safe filament. The composition of the nozzle and hot spots for bacterial growth should be carefully considered during design and manufacturing.
- 3D printed parts may still be effective for early prototypes, with the caveat that the final prototype is not food safe, but is intended to be in the final product.

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Americans with Disabilities Act Research

Introduction

The Park School, through its partnership with the McCormick School of Engineering's DTC program aims to create a device that would enable their students to perform the action of pouring without the teachers having to intervene. Park School is a public therapeutic day program committed to serving a wide range of students with disabilities, ages 3 through 22. Students who study at Park School have an identified disability in one or more of the following categories: moderate to significant Intellectual Disability, Autism, Deaf and Hard of Hearing, Visual Impairment, and/or Multiple Disabilities. They have an existing solution; however, teachers have to constantly refill the dispenser and change the cup that the dispenser pours into, preventing students from independently completing the task. This holds students back from completing the task by themselves. In this document, first, I will state the ADA Requirements and the standards we must abide by when designing. Then, I will talk about the PowerLink's working mechanism and the switch activation process.

ADA Requirements

The Americans with Disabilities Act (ADA) is a federal civil rights law that prohibits discrimination against people with disabilities in everyday activities. The ADA prohibits discrimination on the basis of disability just as other civil rights laws prohibit discrimination on the basis of race, color, sex, national origin, age, and religion. The ADA guarantees that people with disabilities have the same opportunities as everyone else to enjoy employment opportunities, purchase goods and services, and participate in state and local government programs [1]. In our context, we are trying to create a switch-activated solution that the Students at the Park School would be able to use. Therefore, we are most concerned with the switch-related requirements. According to ADA, the switches should:

- Be operable with one hand
- Not require tight grasping, pinching, or twisting of the wrist
- Be operable with a force less than or equal to 5 pounds [2]

The ADA and the United States Access Board defined regulations to ensure people with different abilities are able to exist independently. The US Access Board is an independent federal agency that advances accessibility through leadership in accessible design and the development of accessibility guidelines and standards [5].

The Operable Parts document, published by the Access Board, reinforces and visualizes these ADA Requirements. It has information regarding the installation of the switches and handles alongside the suitable shapes for buttons. Even though it is not a requirement, the United States Access Board suggests that the push buttons should be raised instead of indented for easier operation. [3] After ensuring the switches are created in a form that is suitable for different ranges of abilities, I will now dwell on how the switches would be incorporated into the solution. I will talk about the PowerLink gadget and how the switch-activation is formed.

Powerlink and Switch System

The use of switches can be applied to any system that requires a single action to start. This can be a starting blender, a light bulb, or a turning plat. However, it would be costly to buy customized basic appliances with accessible switches. For example, for a student to work with a blender, they need a blender that is operated by a button switch, a mount switch, a finger switch, and every other switch they use. This creates the need to buy over five of the same appliance. To overcome this problem, teachers of the Park School started using a device called PowerLink. PowerLink is an assistive technology wireless switch control unit for home automation and accessibility, produced by a single brand called AbleNet. There are alternatives in the market, but they require Arduino, other hardware/software appliances, which makes them harder to use. The powerlink has a very simple and intuitive design. It connects the switch plugged into the appliance, making it accessible for all users. Its flexible outlets allow custom positioning of up to two appliances. [4] It also has two switch input jacks where you can plug in the switches you want to operate the gadget with. [4]

The PowerLink 4 Device offers different modes of control:

- Direct: Behaves like a traditional switch.
- Count: Behaves like Direct, shows the number of activations
- Two-Switch: Behaves like Direct, both switches must be activated
- Timed Seconds: Runs the appliance from 1 to 99 seconds
- Timed Minutes: Runs appliance from 1 to 99 minutes
- Latch: First activation turns the appliance ON; second activation turns it OFF [4]

For our project, the most suitable mode of control appears to be the “timed seconds” one. After going through different phases of client interviews and sketching, we discovered that our problem would require two switches. Both of these switches will be timed and would operate for that specific duration when pressed once. The first switch would be to dispense until the cup is full and the second switch would be to turn the rotating plate for the new and empty cup to come below the dispenser. After having understood the requirements for our project, now we should look into people with limited abilities performing similar tasks and how other designers handled those problems. I will talk about understanding the person in front of you, measuring the data you will work with and various approaches.

Similar Situations and Different Approaches to Increase Accessibility

Awareness around inclusivity has been increasing in different domains ranging from public transportation accessibility apps [7] to public web accessibility [8]. Even though everything is created to accommodate the 95 % percentile of the population, we are coming up with solutions that accommodate the remaining 5% who might require specialized thinking [6]. The most important step in researching accessibility is always empathizing. Empathy doesn't only come from an emotional state, but it should be nurtured from quantitative measurements to understand

the capacities of people who we are designing for. In the context of packaging, when opening a jar lid, a torque sensor was applied to a modified lid to fully comprehend the needs [6]. It is concluded that the packaging should be created to cater to the people who struggle the most [6]. In addition to modifying the current solutions we have, another way of approaching the packaging problem can be training the remaining 5% to increase their abilities. Even though this isn't the easiest or the most applicable way that would benefit everyone, it can have a significant effect on people's sense of independence and belonging, complementing their rehabilitation training [9]. One solution for performing the pouring task is Virtual Reality (VR) training. Through a VR training system equipped with haptic devices, which is supervised by occupational therapists, it is measured that the percentage of water successfully being poured increases after 4 sessions of training [9]. Despite these approaches having major differences in what they are trying to achieve, they all try to address a need through understanding.

Conclusion

Our main goal with this project is to enable students to perform a pouring task that has real-life applications, whether it is in the workforce or their daily lives. Through a new solution, students can pour granular objects into containers, water into cups, soil into a flowerpot, and perform other daily tasks with independence. The main concerns with a future solution are the ADA requirements for switches, so the device is suitable for our students. In addition, we will be using the PowerLink Gadget as it is a solution that is already in use at the Park School. Learning about the PowerLink and its features gives us a perspective on the trajectory we want to follow when prototyping.

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Appendix F: Bill of Materials

Table 4 below displays the items purchased for the device, a description, quantity, number number, as well as unit cost and total cost. This allowed our team to stay in-budget and track our spending over the course of the project.

Table 4: Bill of Materials for the EasyPour Device

Item	Description	Qty	Source	Part #	Unit Cost	Total Cost
Arduino Nano	Microcontroller to manage button input and motors	1	Amazon		15.99	15.99
12V/3A Wall Adapter with Barrel Plug	Adapts wall power to the microcontroller input power	1	Amazon		9.99	9.99
DC Barrel Jack to Screw Terminal Adapter	Adaptor for barrel plug and microcontroller wiring	1	Amazon		3.97	3.97
NEMA 17 Stepper Motor	Motors that move in discrete steps to drive auger and lazy susan	2	Amazon		14.99	29.98
A4988 Stepper Driver	Driver to power stepper motors	1	Amazon		10.19	10.19
3.5mm Mono Panel Mount Jacks	Button jack input mounts	1	Amazon		5.99	5.99
Breadboard	Microcontroller and wiring board	1	NU Mechatronics Lab		0	0

Wires	Breadboard and standard wires		NU Mechatronics Lab		0	0
Polycarbonate Rigid Tube	Clear tubing to house the auger	1	Amazon		6.99	6.99
Tank	Large food-safe tank for holding granular materials	1				
Lazy Susan Bearing Ring	Concentric spinning bearings	1	Amazon		17.99	17.99
Threaded Inserts for Plastic	Brass threaded inserts for 3D printed parts	1	Amazon		6.99	6.99
5mm Flange Coupling Connector	Flange connector to attach to the motors	1	Amazon		6.99	6.99
Dc Power Jack 5.5 Mm	Female connector for the 12V power adapter	1	Amazon		5.28	5.28
					Total	120.35
					Total after Tax	132.69

Appendix G: Instructions for Construction

Overview of the EasyPour

The EasyPour is a horizontal auger dispenser that automatically dispenses dry granular materials and rotates through containers via external buttons. The design consists of a large tank and a funnel for the material to be dispensed, which enters the horizontal auger tube. The auger, driven by a motor, carries the material laterally and dispenses it at a consistent rate. The base plate has a lazy susan top that rotates through containers via a stepper motor, allowing multiple containers to be filled in succession. Both motors are controlled by a microcontroller and powered by a wall outlet, which takes input from external wired button switches that can be mounted in any manner.

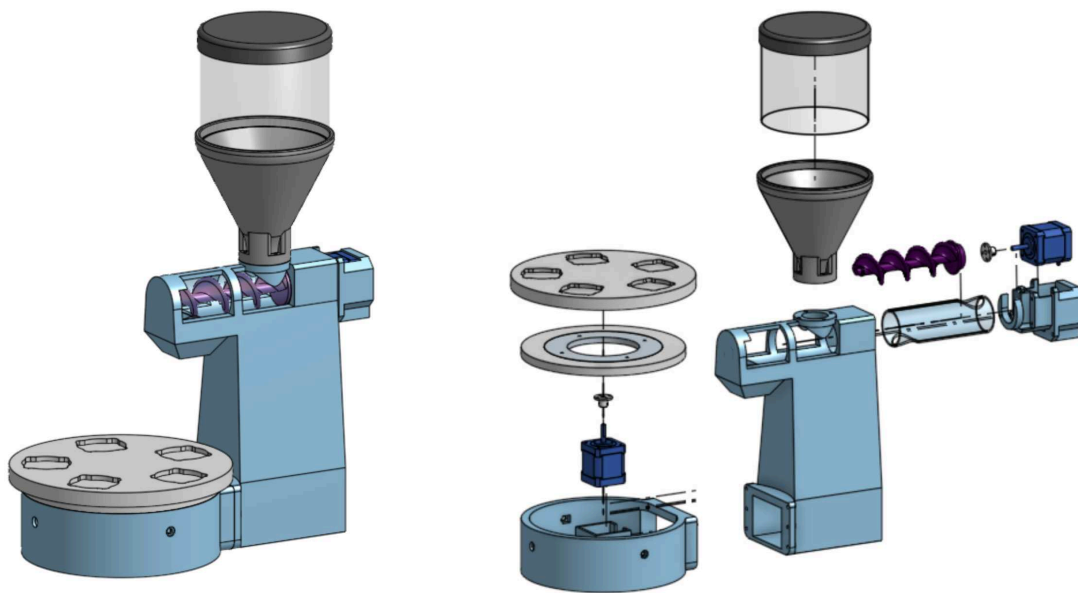


Figure 22: Isometric and exploded view of the EasyPour in Onshape

The exploded view on the right shows each main component of the EasyPour. The baseplate, rotating plate, auger stand, motor case, auger screw, and funnel are 3D printed, while the lazy susan bearing, NEMA 17 stepper motors, flange motor couplings, polycarbonate tube, and plastic container are not 3D printed.

Theory of Operation

By composing the right components and following the step-by-step instructions below, the user should be able to construct a switch-activated auger dispenser with a switch-activated lazy susan. If constructed properly, the 3D printed parts should be able to connect together seamlessly, and external components should fit cleanly with minimal tolerance into the 3D printed shells. If circuitry is completed correctly and all components are functional, the EasyPour should be able to be powered using the supplied 12V wall adapter and the auger and lazy susan should be able

to be independently activated using external buttons. The user should also be able to easily remove the and reinstall the auger and clear tube for washing purposes.

Tools:

- 3D printer
- Soldering station
- Deadblow mallet
- Horizontal bandsaw
- Manual mill
 - V-blocks
 - Circle cutter
 - End mill
 - Edge finder
 - Measuring caliper
- Deburring tool
- Sandpaper
- Allen key
- Screw driver
- Wire-cutter pliers

Step-by-step Instructions

3D Printing

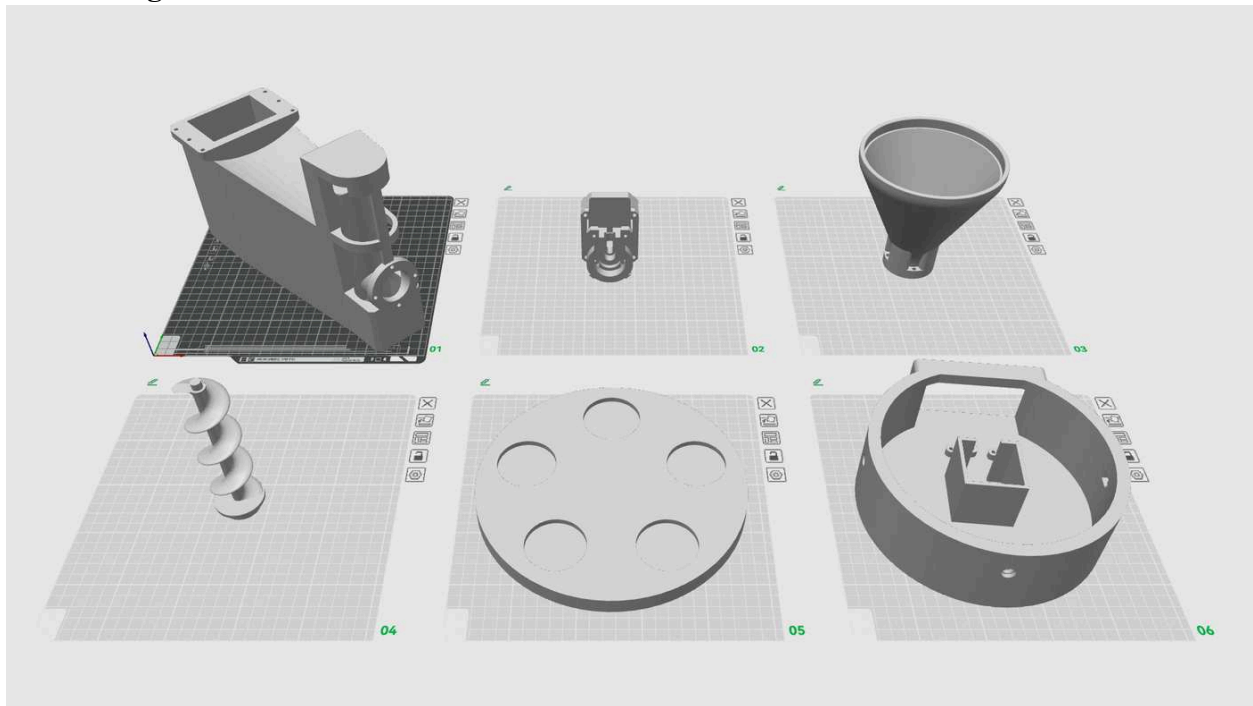


Figure 23: All 3D printed parts and their orientations shown on 6 build plates in BambuStudio

1. Open BambuStudio or a similar program to slice STL files for 3D printing

2. Open the supplied STL files for the Baseplate, Rotating Plate, Auger Stand, Auger, Motor Case, and Tank Funnel into 6 different plates
3. Orient each part using the auto-orient button at the top of the screen
4. Orient the Auger Stand diagonally to fit within the plate bounds of the Bambu Labs X1C printer
5. Set the global settings to 2 wall layers, 15% infill, 25-degree support threshold, and enable tree supports
6. Set the individual settings for the Auger to 4 wall layers
7. Press the prepare button to begin slicing
8. Insert any color filament spool into the 3D printer
9. Send the print request to the 3D printer
10. Wait for the heat bed to cool below 40 degrees Celsius after the print is finished
11. Remove the parts from the print bed
12. Use pliers to carefully remove tree support material from the prints

Heat Set Threaded Inserts

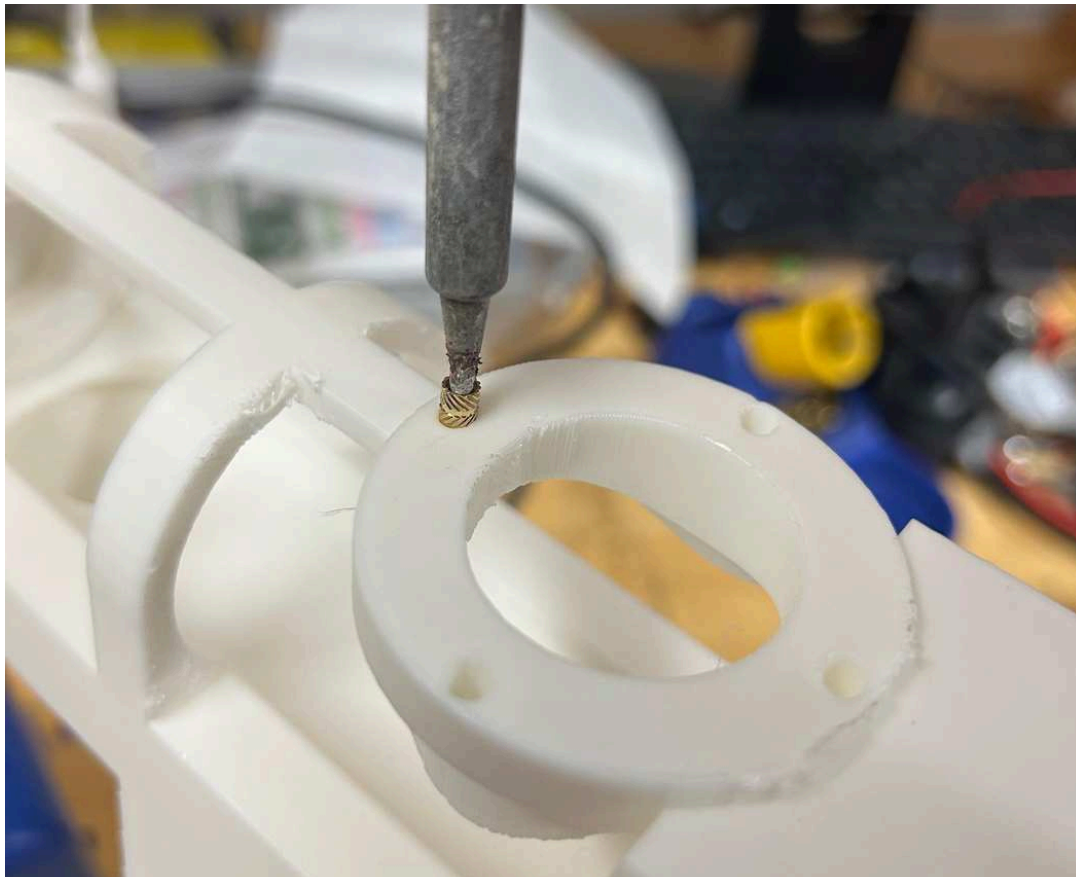


Figure 24: Use of a Soldering Iron to Attach Heat Set Inserts (Note that the soldering iron is held stable and perpendicular to the surface of the 3D print)

1. Place a 6mm M3 heat set insert into each blind hole in the 3D printed parts

2. Hammer the inserts gently with the deadblow mallet until they sit above the surface but no longer fall out
3. Turn on a soldering iron to at least 600 degrees Fahrenheit
4. Place the soldering iron vertically into a heat set insert, ensuring the iron is perpendicular to the surface
5. Apply gentle downward pressure to the insert until it is flush with the 3D printed surface
6. Repeat with all remaining heat set inserts

Polycarbonate Tube Milling

A Bridgeport mill and horizontal bandsaw were used to machine the polycarbonate tube in the prototype; however, a drill press and hand saw can be used for a more crude product by following the engineering drawing below.

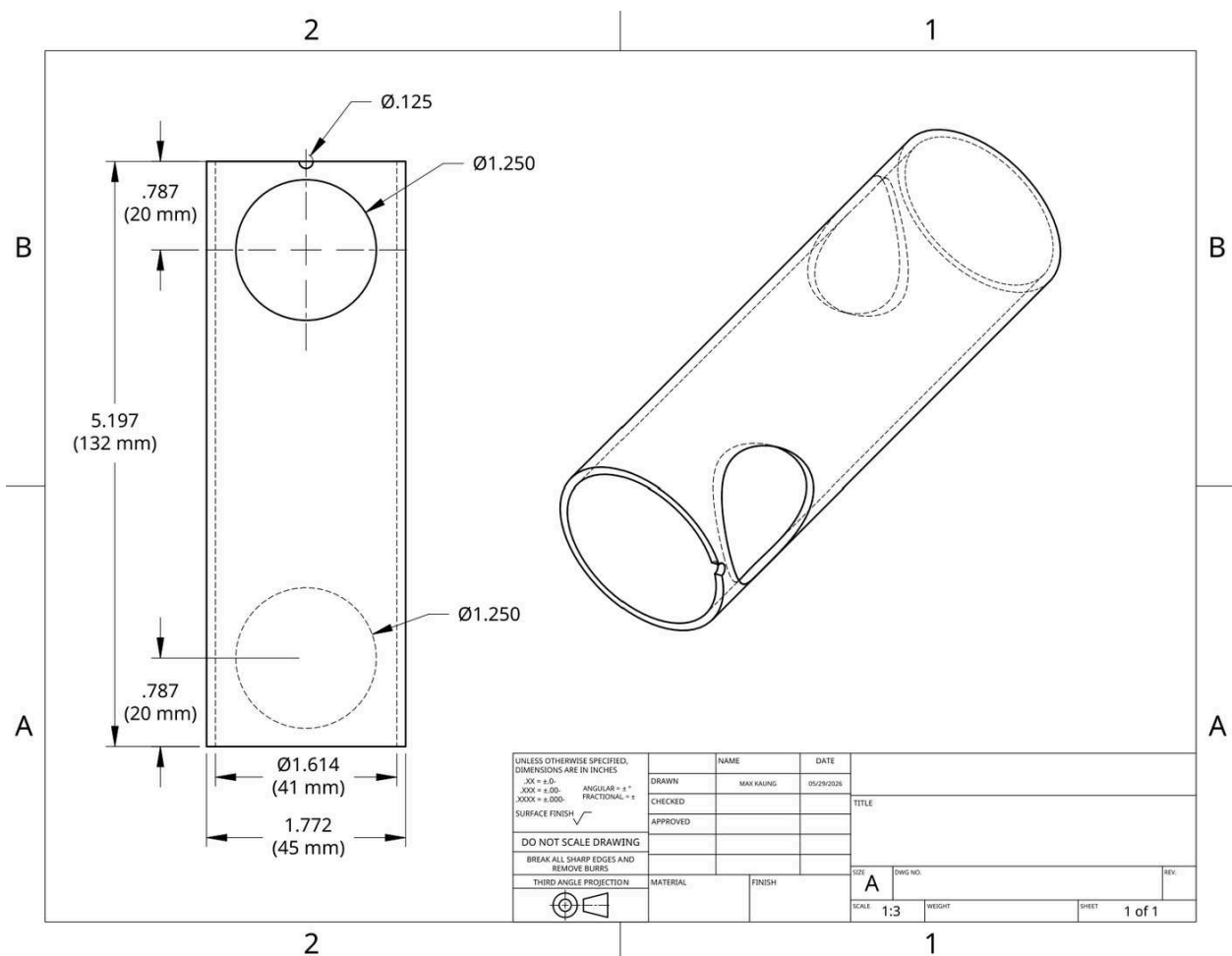


Figure 25: Engineering Drawing of the Polycarbonate Tube for Milling Reference

1. Cut the polycarbonate tube to about 5.25" using the horizontal bandsaw
2. Place the tube between two V-blocks in a Bridgeport mill vice

3. Tighten the vice firmly to ensure the tube does not kick up during drilling, but avoid extreme deformation of the tube
4. Use an edge finder to zero the mill to one end of the tube and the longitudinal center of the tube
5. Drill the hole and semicircle into one side of the tube following the engineering drawing using a circle cutter and end mill
6. Rotate the polycarbonate tube 180 degrees
7. Use the edge finder to rezero the mill to the opposite side of the tube
8. Measure the length of the tube using a caliper
9. Use an end mill to cut the length of the tube down to the nominal length shown in the engineering drawing
10. Drill a hole into the other end of the polycarbonate tube, following the engineering drawing
11. Use a deburring tool to remove any sharp edges and plastic flakes

Plastic Container Cutting

1. Use scissors to cut off the bottom platform of the plastic container, ensuring the entire flared bottom is removed
2. Use the scissors and deburring tool to ensure the bottom cut is smooth and sits flat

Circuitry

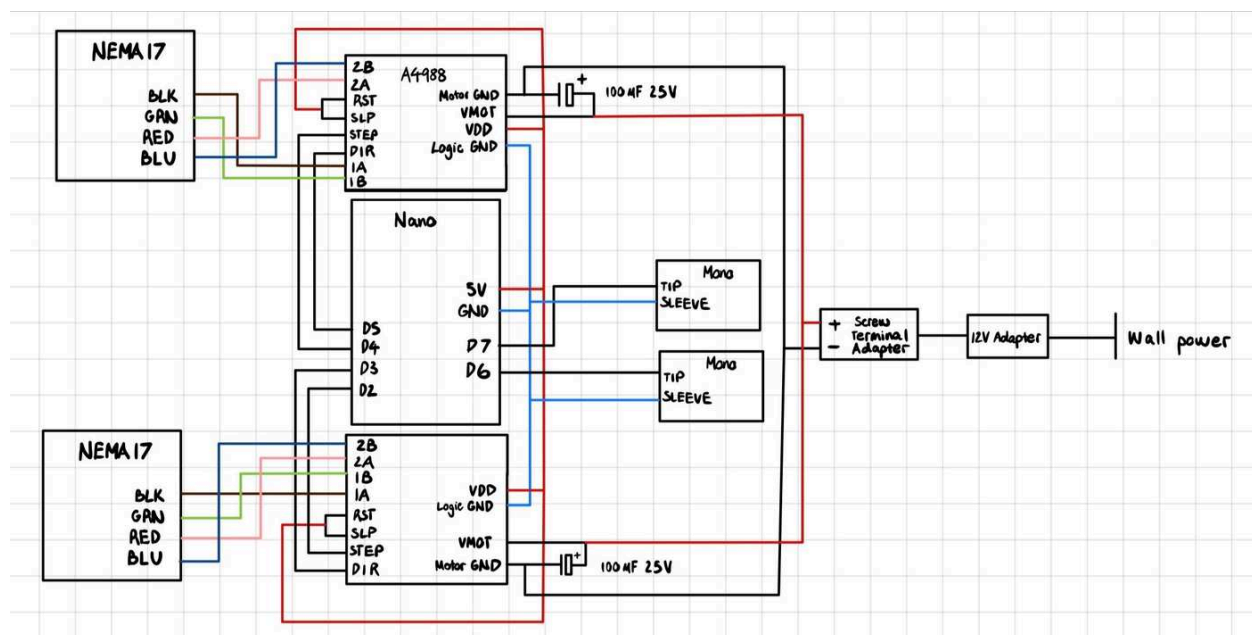


Figure 26: Circuitry Diagram for the Perforated Board

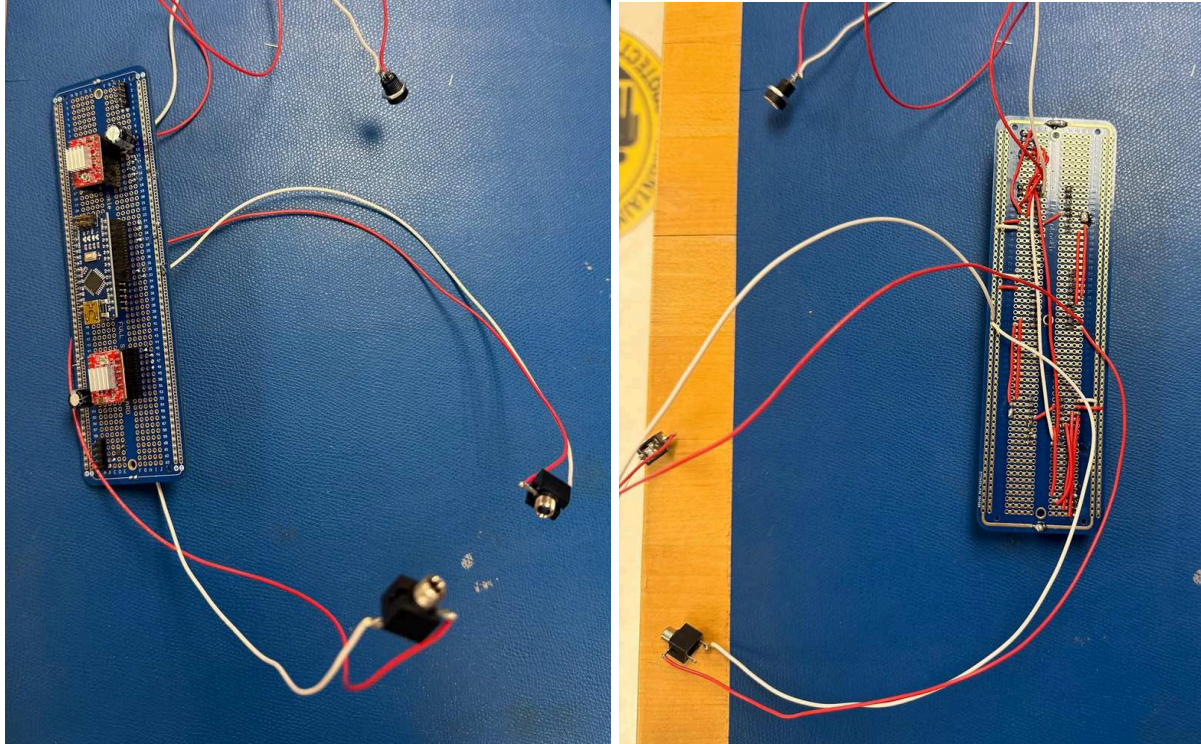


Figure 27: Completed Circuit Soldered onto the Perforated Board (Note the top connections are shown on the left, and the bottom wiring is shown on the right)

1. Turn on a soldering iron to at least 700 degrees Fahrenheit
2. Insert the power port into the Baseplate from the outside
3. Attach the nut to the inside of the power port to secure it
4. Solder the button ports, power port, capacitors, connector pins, and wiring to the large perforated board, following the above circuit diagram
5. Flash the supplied code onto the Arduino Nano microcontroller
6. Attach the 2 stepper motor drivers, stepper motor wires, and Arduino Nano to the connector pins

Final Assembly

The exploded view in Figure 1 can be referenced for assembly.

1. Prepare all required components: all 3D printed parts, 2 NEMA 17 stepper motors, 2 5mm flange couplings, the machined polycarbonate tube, the cut plastic container, the lazy susan bearing, and various lengths of M3 screws
2. Install the flange couplings onto the NEMA 17 stepper motors by inserting the grub screws into the sides of the couplings with an Allen key
3. Attach the NEMA 17 stepper motor and the inner ring of the lazy susan bearing to the rotating plate by screwing into the heat-set inserts
4. Screw the completed perforated board into the floor of the Baseplate

5. Slip the wire of the other NEMA 17 stepper motor through the bottom of the motor case and from the top to the bottom of the Auger Stand
6. Attach the Auger to the stepper motor coupling
7. Slide the NEMA 17 stepper motor snugly into the motor case
8. Slide the polycarbonate tube into the top of the Auger Stand so that the nub fits into the slot at the end of the tube
9. Slide the stepper motor and motor case into the polycarbonate tube, ensuring that no wiring is caught between the 3D printed parts
10. Secure the motor using 4 screws
11. Plug the NEMA 17 stepper motor cord from the bottom of the Auger Stand into the perforated board
12. Press the button ports into the sides of the Baseplate from the inside
13. Attach the nuts to the outsides of the plug ports to secure them
14. Slide the Baseplate and Auger Stand together, ensuring that the perforated board rests above the supports in the Auger Stand
15. Secure the Baseplate and Auger Stand together using 6 screws
16. Attach the Tank Funnel to the top of the Auger Stand using 4 screws
17. Press the cut plastic container into the top of the Tank Funnel

Appendix H: Instructions for Use

Introduction

These instructions will cover the following sections:

- (1) Preparing the EasyPour for use
- (2) Using the EasyPour
- (3) Removing and reinstalling the auger for clearing or clearing a jam

Using EasyPour requires no experience or background knowledge. The user should be able to complete the product setup independently within 1-2 minutes.

Parts List

- EasyPour
- 2 external mono Jack switches
- 12V wall adapter
- Dry granular material

Safety Information

CAUTION — Potentially Hazardous Mechanical Movement

Refrain from putting fingers or clothing near the entrances of the clear tube while the auger is moving. Appendages caught between the auger screw and the tube may cause pinching.

WARNING— Electricity

Use the supplied 12V wall adapter. Do not expose the EasyPour circuits or power cords to water or extreme conditions. Do not wash EasyPour components while plugged in. Take care when handling the stepper motors near water. Refrain from keeping the EasyPour plugged in for more than 8 minutes at once.

Preparing the EasyPour for Use

Parts required: EasyPour, 2 external mono Jack switches, 12V wall adapter, dry granular material

1. Place the EasyPour on a flat, stable surface
2. Pour the granular material to be dispensed into storage container above the auger
3. Place up to 5 plastic cups into the slots on the rotating plate
4. Prepare any necessary switch mounts
5. Plug in both mono switches into either side of the EasyPour
6. Plug the 12V adapter into the wall and plug the port into the EasyPour.
 - a. The EasyPour will click when the stepper motors are powered
7. Manually rotate the rotating plate until a cup is centered under the auger exit funnel
8. The EasyPour is ready to be used to fill 5 cups without instructor interference

Using the EasyPour

Parts required: Prepared EasyPour

1. Press the button connected to the left side of the EasyPour to begin rotating the auger, filling a single cup
2. Press the button connected to the right side of the EasyPour to rotate the Lazy Susan 72 degrees to the next cup

3. Continue pressing the buttons in that sequence until all containers are filled or all material has been dispensed

Removing and reinstalling the auger

Parts required: EasyPour, screwdriver

1. Use the screwdriver to remove the 4 screws securing the motor case to the back of the auger stand
2. Carefully remove the motor and auger from the auger stand horizontally
 - a. If the auger still has material in the clear tube, remove the auger over a plate or tub to catch the granular material. Then tilt the auger stand to remove any remaining material in the tube
 - b. Take care not to remove the motor too far from the auger stand. Don't tug on the motor wires
3. Slide out the clear tube from the auger stand
4. If the auger needs to be cleaned, wipe carefully with a damp towel and dry immediately
 - a. Take care not to wet the motor or wires
5. If the clear tube needs to be cleaned, wash by hand and dry before reassembly
6. Clear out any dust or material from the auger stand
7. Reinsert the clear tube into the auger stand
 - a. The small slot on the edge of the tube should go in first, aimed downward. The slot should fit in with a nub on the opposite end of the auger stand
8. Reinsert the auger and motor into the auger stand, angling it slightly upward to allow the auger to slot into the bearing on the other end of the auger stand
 - a. The wires on the motor should be aimed downward. Take care to stuff the wires into the auger stand and not pinch any wires
 - b. The motor case should sit nearly flush with the back of the auger stand
9. Screw in the 4 screws
 - a. The screws should not be screwed in too tight. They should only be tightened until resistance is felt and the screws no longer shift during use

Troubleshooting

Below is a table that details how to troubleshoot the device:

Table 5: Troubleshooting Problems, Causes, and Solutions

Problem	Probable Cause	Solution
The EasyPour's auger stops moving material laterally.	The auger is jammed, likely by material getting caught between the auger blades and the entrance hole.	Run the auger several times until the jam clears. If the jam is persistent, pour out the material from the storage container and remove the auger and motor to clear all material from the auger tube.
The EasyPour's rotating plate does not align well with the	The stepper motor was not manually aligned after being	Manually align the rotating plate while the EasyPour is

output funnel.	first powered on.	plugged in.
The EasyPour's 3D printed parts do not sit flush during assembly.	Wire or material is caught between the two surfaces of the 3D printed parts.	Wipe off any material or stuff any wire into the EasyPour's internal chambers before tightening screws.

Appendix I: Ethical Considerations

Our team is developing a switch-operated system that would enable students at Park School with limited arm control to perform a pouring task. The pouring task would include filling salt shakers or cups with granular materials such as salt, beans, or rice. The problem with their existing solution is that the teacher has to refill the cup that will be poured and replace the container that is filled every single time. During our meeting, we established that our 3 main ethical concerns are physical accessibility, cost efficiency, and safety considerations.

Physical Accessibility

We are committed to ensuring physical accessibility by adhering to ADA standards, which guarantee that both our prototypes and final product are usable by individuals with diverse abilities.

Cost Efficiency

We will aim to maximize financial feasibility so our solution can benefit as many students as possible.

Safety Considerations

We will look into the safety concerns by prototyping and defining the problematic areas that might cause safety concerns.

Overall, our goal is to create a safe, accessible, and cost-conscious system that increases student independence while reducing the need for constant teacher intervention.

Appendix J: Client Interview Summary

Introduction

This document summarizes the interview conducted with our project partner, Park School, which is located in Evanston, Illinois. Park School is a public therapeutic day program committed to serving a wide range of students with disabilities, ages 3 through 22. Students who study at Park School generally have an identified disability in one or more of the following categories: moderate to significant intellectual disability, autism, deaf and hard of hearing, visual impairment, and/or multiple disabilities. Our goal for the interview was to better understand both the physical and emotional needs of students who wanted to conduct the task of pouring, as well as our client's needs.

For this interview, the representative and the interviewee was:

Jennifer Flaxman, Transition Coordinator, Teacher of the Deaf and Hard of Hearing
Park School, Evanston, IL
Tuesday, April 28, 2026, 3:30 PM - 4:30 PM
GoogleMeet

The school's ultimate goal is to cater to every student's individual needs and support them through their academic journey and beyond.

Focus of the Interview

The interview focused on:

- Understanding the student population
- Clarify the two root causes for the design needs: the cup that pours and the cup that gets filled
- Comprehend the emotional need of why a student might need our solution
- Figure out the problems with the already existing solution
- Recognize the range of physical limitations student users may have

Results

Program Context and Student Population

Park School welcomes students from ages ranging from 3 to 22. Students' abilities differ from one another; therefore, they have a tailored curriculum and a way of teaching for every student. However, students generally experience trouble when using their arms when performing acts of pushing, pulling, grabbing, or holding, which prevents them from turning things on/off easily.

Different Types of Switches Used

Park School tailors their education to the individual needs of its students. Therefore, they use different kinds of switches for different types of assistive needs. Most of the time, they are using:

- Button Switches
- Switch Mounts
- Microlight Switches

Students can operate the switches using whichever body part they are comfortable with such as their:

- Chin
- Head
- Fingers
- Wrists

During the interview, we observed videos of students actually performing tasks and using the switches, where a student activated drums with his head with the mounted switch, or a student activated the switch with their wrist to pour dirt into little cups.

Making the Switches Work

Considering that it would be very expensive and inefficient to buy machines that included switches for each need of different students, the Park School came up with a solution. They are utilizing a gadget named “Powerlink”. PowerLink works through two ports, in which you plug the machine that you want to make work and the switch that controls the machine. This way, the powerlink gadget can turn every machine that is activated by a button, from a blender to a pourer, into switch-activated devices.

Problems with the Existing Pourer

We got the chance to clarify the scope of our project, which came from 2 different problems. Their existing pourer uses a small plastic pitcher rotated by a motor either clockwise or counterclockwise very slowly.

- The “pourer” cup has to be refilled by the teacher each time the student wants to perform this task.
- The container into which the material is being poured from has to be placed by the teacher below the pourer cup.

In addition, they lack the quantity of machines as the existing pourer is the only one that they have. They are hoping that we find a solution that fixes both of these problems by having a switch-activated dispensing system that utilizes a rotating carousel to hold multiple containers.

Their vision is that students can participate in pouring activities and can complete multiple steps without the instructor needing to intervene. They want students to be able to hit the switch and fill more than one container independently.

Emotional Need Behind the Pouring Act

The students we work with experience different types of disabilities that create barriers for students to complete tasks without requiring help. If we were to reminisce about our own childhood, we would definitely remember our parents encouraging us to complete tasks independently. We would be proud to show our achievement to them, we would be proud of ourselves, and they would be proud of us. This gives us self-esteem and creates the way to self-actualize. Similarly, the students at Park School also need to fulfill this need. As we were able to observe in the videos, the kids' eyes lit up as they were able to complete the task assigned without requiring help. They seemed very happy and proud of themselves. Even though the pouring task currently requires help, it presents a clear opportunity for innovation. We are not just here to ease their way of completing a pouring task, but we are here to show them that they can perform tasks all by themselves. We are here not only to add a new skill to their skillset but also to attempt to improve their quality of life.

Target Users

Park School has students ranging from 3 to 22, but the target audience for the switch-activated system is students who would work in nearby restaurants to fill salt/pepper containers in the future or pour water for their classmates. We are hoping to help all students who would be able to complete these single-step tasks.

Core Needs

- Be easy to use
- Maintain a minimal design
- Be accessible to users with different abilities
- Complete the pouring task independently
- Eliminate the need for teacher intervention
- Allow students to complete the task multiple times without asking for help
- Maintain alignment between the dispenser and cups to reduce spillage

Safety and Durability

Key constraints include:

- Avoidance of sharp or pointy elements
- Shouldn't require a very precise and big push from the student
- Durable to accidents where it would fall/drop, etc.
- Designed as a stationary solution, but portability must be expected

Inclusivity and Aesthetics

Inclusivity, for Park School, means:

- Students with different abilities can operate it

- Students feel accomplished when performing a task
- Students have a sense of belonging and improve their self-esteem

There are no strict aesthetic limitations, but we should ask students and teachers for their opinions. For example, do bright colors help them locate the switch better, or should sound be a factor we consider? In addition, teachers mentioned that they had carts that enabled them to transport gadgets from one classroom to another; therefore, sizing isn't a major problem.

Discussion and Design Implications

This interview made it very clear that we should not only be designing for a dispenser system, but we should also automate the rotating system underneath to bring cups that would be filled. Things to remember as we move forward with the design process:

- Adaptability: Our solution must be adaptable to different tasks, whether it is filling salt/pepper shakers or filling up rice containers. In addition, she added that even though it isn't a must, the containers being able to handle liquid would also be a bonus.
- Ease of use for different abilities: Our solution should be easy to use to accommodate a range of different mobility abilities
- Behavior-aware design: All elements must anticipate misuse and remain safe and durable.
- General education alignment: Our solution should feel familiar and empowering, supporting their long-term goals, like getting a job, and short-term goals.

Next Steps

Potential next steps discussed include:

- Observations of students using
- Prototyping and testing design concepts
- Follow-up questions via email

Appendix K: Mockup Sheets

Below are four figures of mockups used in the early stages of ideations. These were crucial to developing our final device.

Figure 28: Initial Mockup of the Lazy Susan Plate

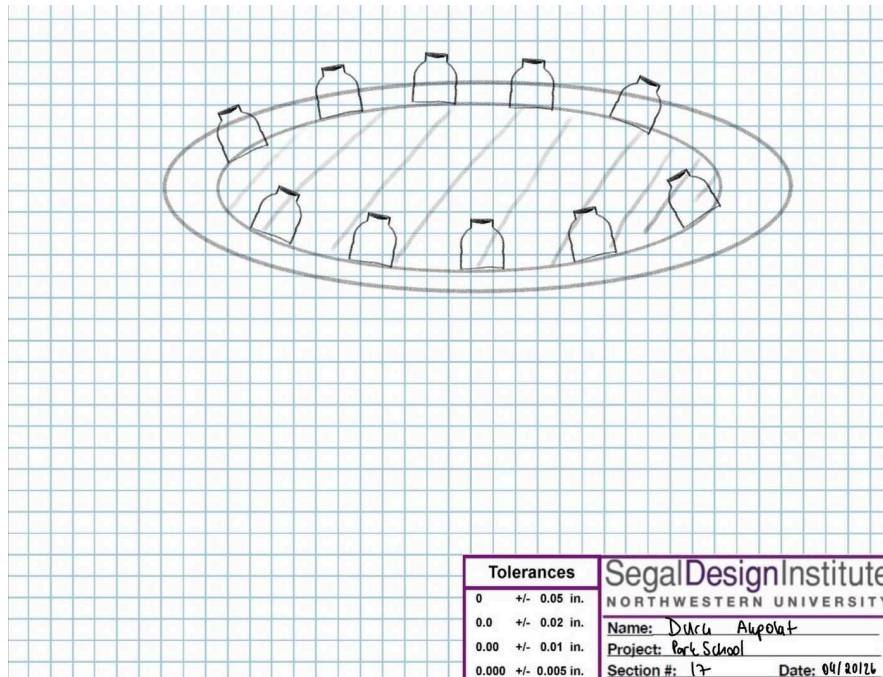


Figure 29: Initial Mockup of the Dispensing Auger

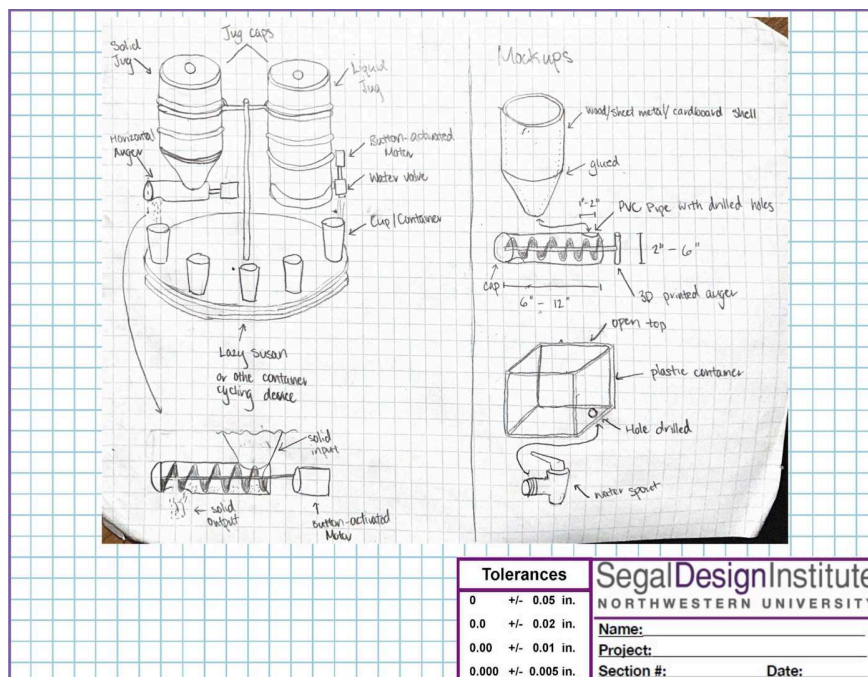


Figure 30: Initial Mockup of the Accessible Inputs

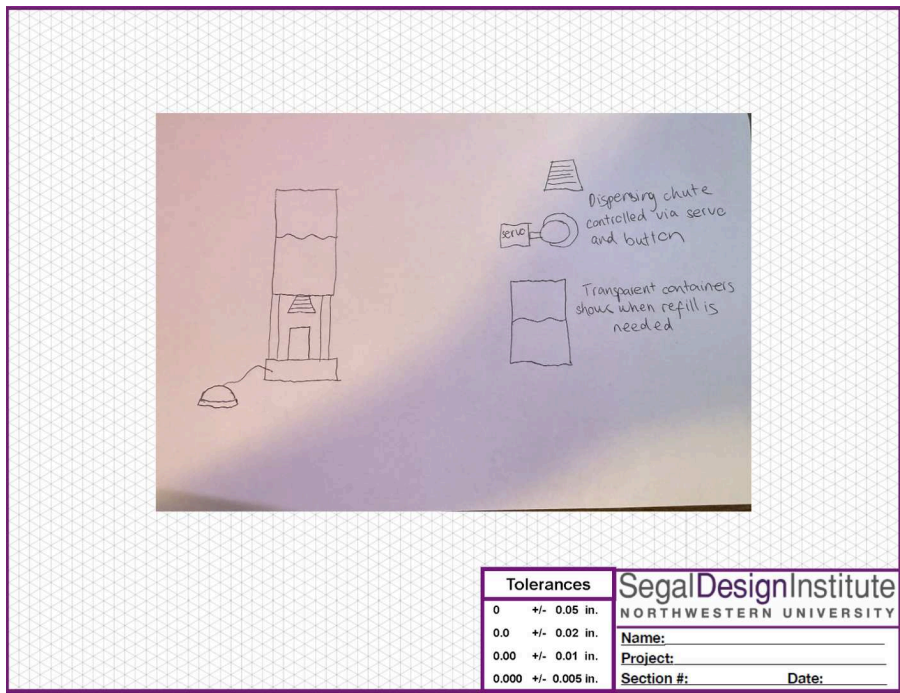
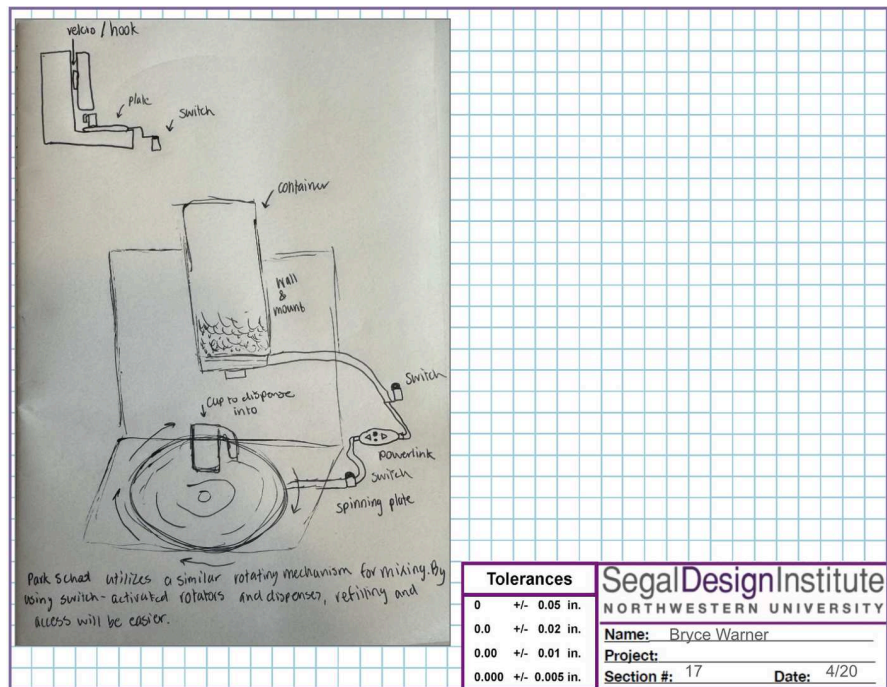


Figure 31: Initial Mockup of the EasyPour Device



Appendix L: Design Review Summary

Introduction

On May 12th, 2026, our team presented a design review of a device intended to help Park School students dispense granular materials with more independence. The current Park School device allows students to activate a switch that tilts a measuring cup, but the device still requires that teachers load the material, position the container, and reset the task after each pour. Our proposed design combines an auger-based dispenser with a rotating Lazy Susan platform with accessible switches activating both, allowing students to dispense materials into multiple containers more independently. In the presentation, we demonstrated our early mockups and presented our current design and sought out improvements on the auger dispenser, rotating Lazy Susan plate, the motors, and the mechanism of control.

The feedback we received focused on motor selection, dispensing accuracy, accessibility, and material variability. Those reviewing did not question the dispensing or Lazy Susan concept, but questioned smaller details about whether our design could support continuous motion and provide enough torque for rotation, provide accurate dispensing, and have simple student operation. Below is a table summarizing our feedback.

Table 6: Summary of Design Review Feedback

Focus Area	Feedback Received	Importance	Impact
Motor choice	A regular servo may not work because an auger needs continuous rotation; servos only operate in degrees	Servos have a limited range of motion, but based on the material, the auger may need to keep spinning to move material to be dispensed	We should compare a continuous-rotation servo, a DC motor, and a stepper motor
Control accuracy	Can the motor be turned an exact amount to rotate the plate	Dispensing accuracy depends on how much the auger rotates; it can differ based on the material	A stepper motor may be best if we need precise, repeatable dispensing
PowerLink	PowerLink may be more like an on-and-off switch rather than a changeable controller,	It may not be necessary as programming the system based on time may not provide	The microcontroller should handle the sequence and input, maybe not use the PowerLink

	questioning the necessity	accurate rotation and dispensing	
Accessibility	Design requires at least two buttons, which complicates accessibility	Too many inputs will make the device difficult for students to learn and operate independently	Limit the design to two buttons and make them very self-explanatory, and combine multiple processes into one
Leakages	Salt or small grains may leak through the auger during use, causing it to clog or overdispense	Leakages would make the device messier and provide less accuracy	Need to test real materials and consider design addenda that would prevent leaking, such as changing the angle of the auger and tube

Main Takeaways

The most important feedback was about the motor used to drive the auger. Because the auger needs continuous rotation to move material through the tube, a standard limited-rotation servo will likely not perform optimally for our design. Furthermore, a continuous-rotation servo could work, but it will be hard to control exact amounts and may not provide enough torque. A DC motor would also rotate continuously, but they require timing-based calibration, which complicates the design. Instead, using a stepper motor is likely the strongest option, so we can opt for precise control over dispensing.

We also received feedback about the PowerLink fitting into the system. If the PowerLink only turns the device on and off, then it only adds additional steps to the design. We have not opted for timing-based solutions for rotating the Lazy Susan, making the PowerLink an additional, unnecessary step. Because the microcontroller is handling the actual input and sequence, removing the PowerLink decreases complexity for the teachers of Park School, as they will only need to plug buttons into the microcontroller rather than the microcontroller and a PowerLink.

Another concern was about material leakage and flow. Smaller materials like salt may leak through gaps between the tube and the auger, while large materials like beans may clog the dispenser or the auger, causing uneven dispensing. Because of this, we want to test how differing angles of the auger and motor affect real material dispensing as a way to finalize the design.

Action Plan

Below is a table detailing our next steps:

Table 7: Action Plan for Next Steps for Designing

Action Needed	Purpose	Timeline
Research different motors, including types, torque ability, power needed, etc.	Choosing the best motors to power the auger and the Lazy Susan	This week
Order necessary electronics	Move from conceptualizing design to prototyping	Today
Design parts in OnShape	Using CAD to print our materials	This week
Test salt, rice, and beans in the newly printed auger	See how different materials flow in our auger and what adjustments can be made before attaching the auger to the mount	After parts 3-D print
Decide on PowerLink	Keep the design easy to understand and operate	This weekend
Order outside parts and build in CAD in the meantime	Provides a stage between mockups and prototyping, allowing for testing usability before finalizing design	This week

Conclusion

Overall, the design review showed us that the auger and Lazy Susan have potential to make dispensing more independent for Park School, but our team has to clarify the motor, controller, and user input. Our next steps are to order parts, design parts in CAD, and 3-D print pieces and test them with real materials, allowing us to determine whether or not our device can dispense without leaking or clogging. These tests and designs that were built off the design review will allow us to make better decisions about our design and support Park School's initiative of increasing student independence.